ENGINEERING NEWS

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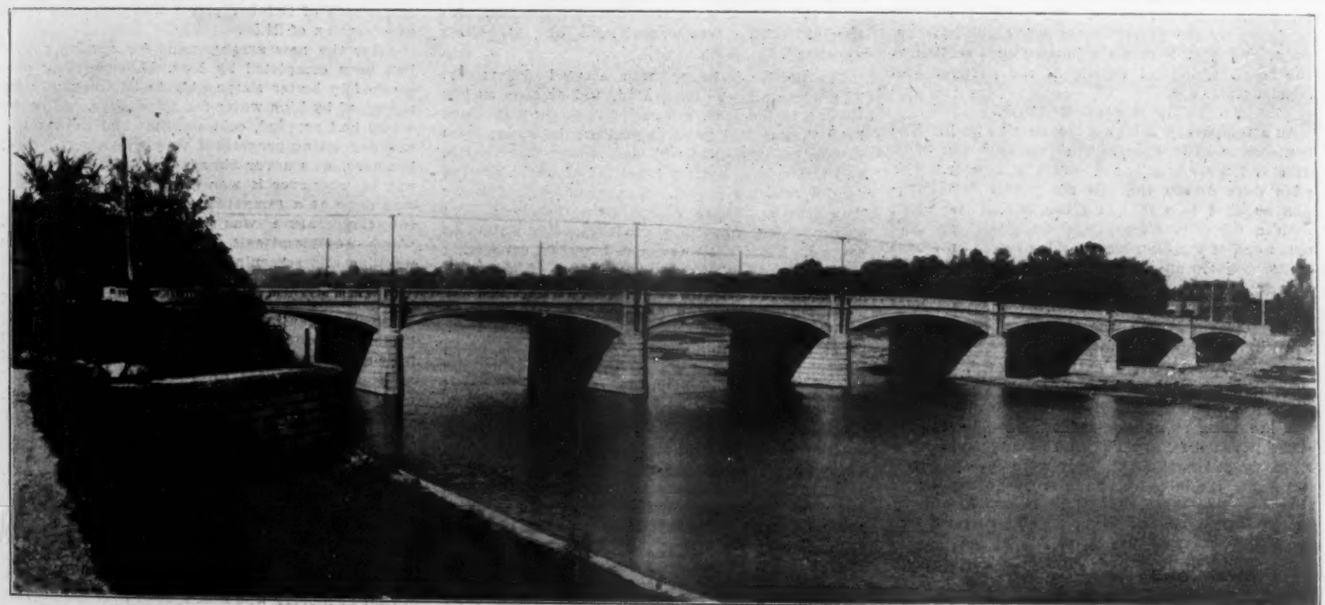
MELAN CONCRETE-STEEL ARCH BRIDGE ACROSS THE GREAT MIAMI RIVER, DAYTON, OHIO.

The old bridge across the Great Miami River on Main St., in Dayton, O., was a steel bridge of the suspension type, built by D. H. & C. C. Morison, of Dayton, in 1871. It had been insufficient to accommodate, properly, the increasing traffic between the city and the suburb, Riverdale, for some years, and when it became necessary to accommodate in addition two traction lines, the building of a new bridge was decided upon. The desire for a more permanent bridge, which would not be subject to the continual expense for maintenance and repairs, as the old steel structure had been, was quite general; but it seemed doubtful whether under the conditions any masonry arch bridge would be feasible.

The Great Miami River at that point is confined in its bed by levees, as the high water frequently rises considerably above the adjoining parts of the city. The low water elevation is about 20 ft., and the high water mark 40 ft. at the south levee, and 39 ft. at the north levee, the difference being due to the current and a bend in the river. The elevation of top of both levees was 43.52 ft., only 3½ and 4½ ft., respectively, above high water mark. Main St. ascended to the south levee with a grade of about 2½ per cent., and descended from the north levee with a 3.8 per cent. grade. Under these conditions it was imperative not to obstruct the waterway more than absolutely necessary, so as not to increase the danger of flooding the city; while, on the other hand, the floor elevation of the new bridge had to be kept as low as possible in order not to increase the already heavy grades of the approaches. A stone arch bridge, aside from its prohibitive cost, was, therefore, out of the question. After considerable investigation by the Board of City Affairs and Mr. F. M. Turner, City Civil Engineer, it was concluded that a concrete-steel bridge at this location would best meet the requirements for a permanent bridge. Thereupon the Concrete-Steel Engineering Co. of New York city was instructed to draw plans and specifications for such a structure, which were to be placed on file for competitive bidding.

The plans, as designed, provided for a seven-span Melan concrete-steel arch bridge, of a total length of 588 ft. between abutments, and 54 ft. wide in the clear. The springing lines of all arches were located 1 ft. below the high water line at all piers and 1½ ft. below high water at the abutments. The elevation of the roadway at the south abutment was raised 1.8 ft., thereby slightly increasing the grade of the south approach, while the elevation of roadway at the north abutment remained the same as in the old bridge. The length of spans ranged from 69 ft. at the ends to 88 ft. for the center arch, while the proportion of rise of arch to length of span increased from 1-13 to 1-10. In order to reduce the thickness of the piers to a minimum it was determined that all arches should have practically the same horizontal thrust, i. e., the smaller the arch span the flatter it had to be, in order to counterbalance the greater weight of the adjoining longer arch. The strain sheets, which were made for the four different spans, show that the horizontal thrust ranges from 88,500 lbs. to 91,500 lbs. per lin. ft. The arches were dimensioned for a live load of 150 lbs. per sq. ft., and two lines of 40-ton electric motor cars. The distance between crown of arch and crown of roadway measures from 13 to 15 ins., so that the railway tracks practically rest directly upon the arch at the center of each span, causing heavy concentration of loads at these points.

The piers and abutments were dimensioned for a maximum pressure of about 4 tons per sq. ft. on the foundation, which was supposed to be good, soEd gravel and sand. However, a clause was embodied in the specifications, providing for a pile foundation in case it should later be found



MELAN CONCRETE-STEEL ARCH ACROSS THE GREAT MIAMI RIVER AT DAYTON, OHIO.
F. M. Turner, City Civil Engineer, Dayton, O.; The Concrete-Steel Engineering Co., New York City, Consulting Engineers.

necessary in any of the piers or abutments. In most other respects the general specifications of the Concrete-Steel Engineering Co. for such structures were adhered to.

Bidders were invited to submit proposals based upon these plans and specifications, which were placed on public file, or to submit proposals for a seven-span plate girder bridge, according to bidders' own design. A separate proposal for a temporary bridge 24 ft. wide, capable of carrying 40 ton electric motor cars, was required of each bidder.

Eight bids were received for a steel plate girder bridge, and seven bids were received on the concrete-steel design. The bid finally accepted was that of H. E. Talbott & Co., of Dayton, Ohio., which amounted to $123,170, and was, of course, for a concrete-steel bridge. The completed bridge is shown by the general view printed on our first page, and Fig. 1 shows a longitudinal section of the 88-ft. span and details of the parapet wall construction, etc.

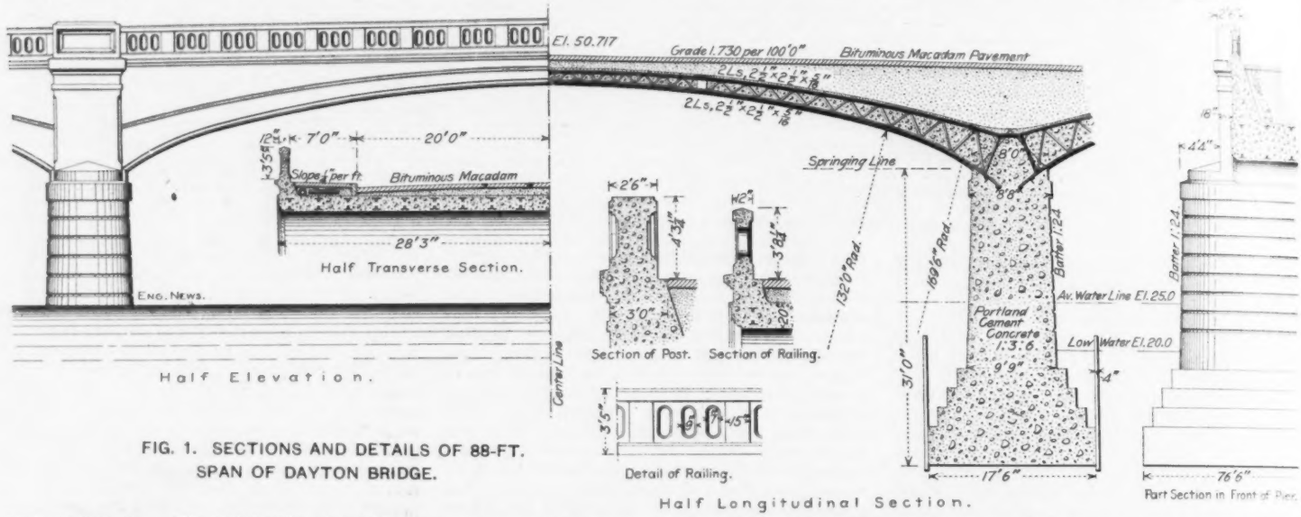


FIG. 1. SECTIONS AND DETAILS OF 88-FT. SPAN OF DAYTON BRIDGE.

TEMPORARY BRIDGE.

As a temporary bridge a trestle was built. The bents were 15 ft. apart. The roadway was 18 ft. wide and there was one sidewalk 6 ft. wide. The piles were driven through the gravel into hard-pan about 4 to 6 ft. below the bed of the river, with a 6,500-lb. Nasmyth steam hammer. The north end of the temporary bridge rested on frame bents. Work on the construction of this temporary bridge was commenced July 22, 1902, and the first car went over it on Aug. 27. Travel across the old bridge was then stopped and dismantling the same commenced.

FALSEWORK FOR ARCHES.

Immediately after finishing the temporary bridge, two pile drivers were rigged to drive piles for the support of the falsework. These piles were driven 8 ft. apart crosswise and from 10 to 12 ft. apart lengthwise. They were cut off 2 ft. 8 ins. below the intrados of the arches, a cap 4 × 12 ins. placed on them, then came two wedges averaging 9 ins., and above these was a stringer 8 × 12 ins., which carried the joists 2 × 12 ins., cut to conform to the curve of the arch. The flooring consisted of 1 in. boards 6 ins. wide.

PIERS AND ABUTMENTS.

EXCAVATION.—Cofferdams for the construction of the piers were built of three pieces of 1-in. sheathing nailed together to form a groove and tongue. The material excavated consisted of gravel under which a layer of hard-pan clay and gravel was struck; this layer was sloping down stream. Piers 1 and 2 were excavated to elevation 12.5, a distance of 7½ ft. below low water and about 5 ft. below the bed of the river. As soon as the excavation of pier 1 was finished, driving of piles 3 ft. centers was commenced. These piles were also driven with a 6,500-lb. Nasmyth steam hammer, and driving was stopped when the penetration with about 15 strokes did not exceed 1 in. The average total penetration of the piles did not amount to more than 8 to 10 ft. Judging from the way the piles drove, there must have been a layer of hard-pan at a depth of 12 to 15 ft. below the river bottom about 3 ft. thick. Piles that were driven through this hard-pan struck gravel again and drove easier.

The excavation in Piers 3, 4, 5 and 6 was only carried down to elevation 14. In piers 5 and 6 no hard-pan was struck; in pier 5 piles were driven 20 ft. without striking hard-pan.

In excavating the south abutment, after being down to near the water line a strip 20 ft. wide running back to some distance from the face was carried down to elevation 11.50. A layer of clay was struck at an elevation of 21, about 3 ft. thick, and below that came water bearing gravel. One pump would easily take care of all the water. This piece was excavated up above the water level and then the rest was excavated and concreted. No special trouble was experienced on this south abutment.

The north abutment was started differently. The whole pit was excavated, and as soon as low enough in the rear, a layer of concrete 3 ft. thick by 8 ft. was laid so as to prevent the street from caving in. The material was mostly filled earth, and the natural bottom consisted of water bearing sand overlaying gravel. A great amount of water was struck. Three pumps were, however, kept going which created a draft for the water all around. Finally it was decided to start concreting at the elevation of 14.50 instead of 11.50, as no wash may be expected on this side of the river. Pumping was stopped and the concrete was deposited under the water. It was not before Feb., 1903, that the foundation was in for this north abutment, as the high water level during the winter months greatly augmented the local trouble.

CONCRETING.—It being optional with the contractor to use crushed stone or gravel in the concrete for the piers and abutments, he choose to use gravel, as the river bed is a natural gravel bottom. To procure and to wash and separate the sand from the gravel the contractor put up a 10-in. centrifugal pump and tried to pump the gravel to an arrangement designed to screen and wash the sand and to run the sand and gravel into separate bins. On account of the large pebbles, or rather boulders, which lodged in front of the screen and caused the pumpage of more water than gravel, this scheme did not work satisfactory, and after several weeks trial, was abandoned and another one adopted, which, after some improvements, worked very successfully until the freezing weather. All machinery except boilers which had been put up on the west side of the bridge were then removed to the east side where the new gravel arrangement had been started. This was done Nov. 6 to 11, 1902. This arrangement was as follows: The gravel was excavated by means of an orange-peel run on a moving derrick, and the gravel so delivered was hoisted by means of an endless chain conveyer and dumped at a height of about 25 ft. into a screen; one section of this screen was of ¼-in. mesh and the other two sections were of 2-in. mesh. A stream of water was thrown into this screen and the gravel and sand so washed dropped into separate bins. The larger pebbles were run out on the other end of the screen to be used in the crusher. When freezing weather had set in, this washing and screening of gravel was stopped and unscreened gravel used first only in the abutments, but afterwards in the piers also.

The concrete in the piers was to be of the proportions of 1 of cement to 3 of sand and 6 of stone or gravel, and for the abutments 1 of cement to 3 of sand and 7 of stone or gravel.

The piles in the piers were cut off at about an elevation of 15, and the first batch of concrete was deposited in pier 1 on Oct. 22 at 4. By the end of the month of October pier 1 was concreted up to an elevation of 21.50.

After the new arrangement for getting gravel had been completed by Nov. 11, concreting progressed in better shape only to be frequently interrupted by high water for a few days. After the water had receded, cold weather and snow set in and concreting progressed very irregularly. Work, however, was never abandoned and concrete was put in whenever it was possible. No concreting was done at a temperature below 15°, and when the temperature was below freezing weather, warm water and salt were used in mixing. The washing and screening arrangement of the gravel could not be worked in freezing weather and all gravel which was of excellent mixture was used the way it was taken out by the orange-peel, only large boulders and chunks of dirt, that had caved in, were thrown out. Concreting in the piers and abutments was kept up and on Jan. 13 a night crew was started up to hasten the work ahead. On Jan. 16 the south abutment was finished ready to start the concreting of the arches.

ARCH RING CONSTRUCTION.

The concrete for the arches was composed of 1 part cement, 2 parts of sand, and 4 parts of broken stone that would pass through a 1½-in. ring, but some stone up to 2 ins. was used. The concrete for the arches was mixed medium wet so that light tamping produced a slushy mass. A coat of mortar was first spread over the flooring and then the concrete deposited onto this layer of mortar. At first it was intended to concrete the arches in transverse sections about 15 ft. wide. The skewbacks on the abutments and over pier 1 were run up to that width and then another section was started. On account of an accident the work had to be suddenly suspended on this second section by the night crew, and layers were left of different depths, varying from 4 ins. to 1 ft. or more. Very cold weather set in and the concrete of this section froze entirely through. On the afternoon of the second day following, work was resumed, the layer less than 4 ins. thick was cut out and the other layers thawed out with steam and then concreted as usual. By midnight the following day this first arch was completed. The actual

working time consumed on this arch was about 50 hours.

The concreting on the other arches was done by longitudinal sections comprising generally 5 spaces, concreting was started from the skewbacks on both sides and from the crown towards the skewbacks. The skewbacks were always concreted beforehand for a length of about 15 ft. up the haunches. A partition was put up so that each section was completely finished before another was started. Before commencing the next section the joints were roughened up and a coat of cement mortar applied. Care was taken to get the concrete under the flanges and around the steel ribs. Special tamping irons like those used for tamping under railway ties were used in this. On Feb. 14 the last span was closed.

On March 17 the wedges under span 1 and 2 were loosened and a start was made to take out the falsework. Levels were taken before touching the wedges and the elevation of the spandrel wall fixed at 46.21. Immediately after all wedges in span 1 had been loosened, the elevation sank to 46.16, and after the second span was loosened it rose again to 46.19. On April 13, after all the falsework was taken out of the entire bridge, the elevation had returned to the original one of 46.21. Spans 2 and 3 each settled in similar way from 0.02 and 0.03, and both came back to their original height. After the falsework of the first span had been taken out, span 4 (the center span) settled from elevation 50.67 to 50.61, and came back only to 50.63 after all support were removed. On span 5, 6 and 7 very little change in the elevation was noticed. The wedges were, as a rule, taken out without much difficulty. Only a few, about six in all, had to be chopped out. The wedges in the spans 5, 6 and 7 were harder to get out than those in spans 1, 2 and 3. In order to allow for a settlement the falsework had been raised from 0.1 to 0.15 above the required height. The total real settlement, however, was only noticed in the center span, and this amounted to only 0.04 ft.

MIXING AND DELIVERING CONCRETE.

The aggregates for the concrete were hoisted up an inclined plane in dump cars and dumped into a hopper from where they were introduced into the cubical box mixer revolving on a horizontal axis passing through two diagonally opposite corners; eighteen to twenty turns were given to a batch. After a few turns, water was admitted which passed through the shaft and then the concrete was discharged into boxes on small cars.

For the piers below the elevation 22, the mixed concrete was delivered upon a trestle bridge which was at first constructed west of the new bridge, but after some damage by high water placed east of the new bridge, turn-tables were put at the intersection of the piers, a track constructed over the piers and the concrete dumped right into the piers from the boxes. For the abutment and piers above elevation 22, the concrete was delivered by derricks, one of them being placed on each abutment, and another, for piers No. 2 and No. 3 over span 3, and then for piers Nos. 4 and 5 moved over span 5. To piers Nos. 1 and 6 the concrete was delivered over tracks over span 1 and 7 and the boxes hoisted by the derricks near the abutments. The steel ribs had been bunched together so as to afford room for the men to work in the piers.

For concreting the arches a track was built on top of the falsework of the arches, the concrete hoisted by means of the derrick placed over span 5 and then carried in side-dump cars to the arch to be concreted and then dumped upon a platform; from there the concrete was delivered by wheelbarrows to the proper place, spread and tamped.

The concrete for the parapet walls was partly mixed by hand, the aggregates being wheeled in over the finished arches, partly brought up from the mixers the same way as the concrete for the arches.

The top of the arches were coated with a coat of cement mortar ½-in. thick, over which a coat of tar, out of which the oil had been extracted, had been spread. As the filling material was taken directly from the river bottom, it contained a great amount of water which had to drain off through the drain pipes provided over the piers, which draining process continued for several months.

The material for filling in between the spandrel walls over the piers and arches was dug out by the orange-peel and brought to the derrick to be hoisted up as the concrete had been. On top of the arches a track had been provided for and the material delivered in side dump cars.

On both sides of the bridge, next to the spandrel walls, pipes for natural gas were laid, a 6-in. main on the west side and a 3-in. and an 8-in. main on the east side. Besides these pipes there were under the sidewalks on the east side thirteen conduits built in by the city for future use, while under the sidewalk on the west side the Central Union and Home Telephone companies put in conduits.

The track for the street cars was laid by the railway company, and 7-in. rails were laid on 8-in. ties; on top of the arches only 4-in. ties were used, and sand was used for filling under the 4-in. ties.

The roadway between track and dummy was paved with brick on a concrete foundation of 5 inches and a 1 inch sand cushion. The curb and sidewalks were constructed of concrete. The elevation of curb is 1 in. above the rail, and the gutter is 5 ins. deep, thus the bottom of the gutter is 4 ins. below the top of rail. The width between curbs is 40 ft., the dummy track is 4 ft. 6 ins. wide, and the sidewalks 7 ft. wide. The railings and pedestals are molded concrete, and were made in molds and set like stone.

The bridge was formally opened with appropriate ceremonies and speeches, the Mayor accepting the same from the hands of the contractors on July 22, 1903.

The work was executed under the supervision of Mr. F. M. Turner, City Civil Engineer, Mr. G. R. Stattelmann being his Resident Engineer in direct charge of the work. Occasional visits of inspection were made by the engineers of the Concrete-Steel Engineering Co., of New York, under whose patents the bridge was constructed, and who acted in the capacity of consulting engineers.

THE BILL EXCLUDING NEW YORK CITY from appropriating streams in Dutchess County for an additional water supply, was signed by Gov. Odell on May 14. In signing it, however, he stated that he did so with the sole object of protecting the rights of the residents of Dutchess County, and would summon an extra session of the legislature "if the citizens of New York so desire, in order to permit the framing of a measure that will accomplish the object of securing an additional water supply to the city of New York, as well as protection of vested rights."

DAMAGE SUITS for furnishing contaminated water are to be brought against the Butler Water Co. by an association of the residents of Butler, Pa., who suffered during last winter's typhoid epidemic. The circumstances of the epidemic were fully given in our issue of Dec. 24.

THE ARCHITECTURAL COMPETITION for the Engineering Building and the Engineers' Club Building has been finally arranged and a printed program has been issued by the committee in charge. The general arrangement of the building was set forth in our "Society Proceedings" column on page 327 of our issue of April 28. The following six selected firms of architects are to take part in the competition, and each will receive the sum of $1,000: Ackerman & Partridge, Carrere & Hastings, Clinton & Russell, Lord & Hewlett, Palmer & Hornbostel, and Whitfield & King. If the design of one of these firms is chosen, the $1,000 payment will apply on his commission. In addition, any reputable architect or firm of architects which has been two years or more in practice may submit designs and the best four of such designs submitted will receive four equal prizes of $400 each. All designs must be submitted on or before June 20 next and the examination and award will be made as soon as practicable thereafter. The architect in whose hands the work is placed will receive a commission of 5% of the total cost of the work. The Secretary of the Committee in charge of the competition is Prof. F. R. Hutton, 12 West 31st St., New York City.

THE DURABILITY OF COAL TAR PITCH WATERproofing has been well illustrated in tearing out the arch of the old Park Avenue Tunnel on the line of the New York Central & Hudson River R. R. This tunnel was built in 1872 and the masonry arch was covered with two layers of felt well coated with coal tar pitch. Earth was placed 2 to 3 ft. thick over the crown of the arch. Now after 32 years the waterproofing is in as good condition as when first laid, the sheets of tarred paper being perfectly flexible. Wherever coal tar pitch is directly exposed to the air it dries out and loses its flexibility, but when it is covered with even a few feet of earth it evidently suffers no disintegration. Engineers and architects often accept petroleum residues that resemble coal tar pitch, but do not have lasting qualities, and this doubtless accounts for the prejudice that some have felt for the coal tar product. Mr. A. B. Corthell, engineer in charge of the great work now going on in the yards of the New York Central, this city, told a representative of this journal that in his opinion the coal tar pitch of today is a product essentially the same as that of 30 years ago, there having been no changes in the process of its production. The New York Central R. R. continues to use it because it is cheap, effective and durable.

THE STREET RAILWAY LINES of Greater New York carried over one billion passengers during the fiscal year ending Feb. 29, 1904, the exact figures being 1,036,834,773. This is the first time that the billion record has been reached in the greater city, the increase over the previous year being about 65,000,000. About two-thirds of the passengers are carried in the Borough of Manhattan and about one-third in Brooklyn. The total number of transfers used was 252,853,130. The increase in traffic in Manhattan was almost entirely on the elevated railways, and traffic on the surface lines was about stationary. The explanation is that the improved train service on the elevated lines since the introduction of electric traction has induced many passengers to use these lines in preference to the surface cars.

STEEL CARS OF LARGE CAPACITY are gradually being introduced on European railways, and the Southern Ry. of France, has recently had some 50-ton steel gondola cars built at the Douai Iron Works to the designs of Mr. Moffre, Chief Engineer of Rolling Stock and Traction. Each car has four pressed steel channel sills, of fish-belly pattern, with end sills, bolsters and transoms also composed of pressed steel channels, and having diagonals in the corner panels. The sides are of plank, supported by steel stakes of U-section, and there are two doors in each side. The trucks have Fox pressed steel frames, with a plate spring over each axle box and no equalizers. For the side bearings there is a complete circle of a light T-rail riveted to the side frames and central sill. The draw gear consists of a plain hook with short drawbar surrounded by a volute spring against which the follower bears. At one end is an elevated and partially enclosed seat for the brakeman, the hand brake being applied to all wheels. The dimensions of the cars are as follows:

Length over end sills	35 ft.
Width over side sills	8.8 "
Height from rail to top	7.5 "
Interior dimensions	34.8 × 8.6 × 3.28 "
Wheelbase, total	29.0 "
Wheelbase, truck	5.4 "
Wheels	2.9 "
Weight, empty	15½ tons.
Carrying capacity	50 tons.

EMPLOYMENT FOR ENGINEERS will be furnished by the National Board of Fire Underwriters. This body, comprising about 120 of the most important fire insurance companies doing business in the United States, has undertaken carefully to investigate conditions existing throughout the country, in order to determine if possible more accurately than heretofore where conditions exist which are conducive to the origin or spread of fire and to cooperate with the government—federal, state and municipal—by suggestions for the elimination of such conditions. To carry out this object, a committee has been appointed, known as the Committee of Twenty of the National Board of Fire Underwriters, with instructions to define the congested districts of cities and determine their conflagration hazard and for that purpose this committee is now organizing a staff of Fire Protection Engineers, who will, after careful inspection, make reports on the construction, fire protection, electric hazard and other local conditions of cities, so that recommendations may be made for the adoption of better building laws, the improvement of water supplies and fire departments and the general safeguarding of hazards, including electricity, handling of explosives, etc., etc. For this work the committee will employ a number of men having had a technical education or training in the different branches of engineering which may fit them for work in such a cause. It is believed that the importance of this work will rapidly increase and that this engineering bureau will be a permanent adjunct of the National Board. Men of ability, graduates of technical schools, will therefore probably find in such work an agreeable field for their ambitions, especially as few men at the present time have entered the profession of Fire Protection Engineering, in which there seems to be such a promising future. Application blanks for employment on this corps of engineers have been prepared by the committee and can be procured by addressing Mr. Herbert Wilmerding, Secretary of the Committee, 46 Cedar St., New York.

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In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 325 means that subscription is paid to the 32d week (that is the issue of Aug. 10) of the year 1905; the change of these figures is the only receipt, unless one is sent by special request.

ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see pages 26-27. New copy for standing advertisements should be received ten days in advance of publication; new advertisements, Monday morning. The pages containing "Want" advertisements are held open until Tuesday, and those with "Proposal" and "For Sale" advertisements until Wednesday at 11 a. m.

The engineering profession is to be congratulated that it is to be so ably represented in the conduct of the work at Panama; and the people of the United States are much more to be congratulated that the great work which they have undertaken to perform is in the hands of men who will see not only that it is performed with absolute honesty but also that it is carried out with economy and diligence.

Of the seven members of the Canal Commission, four, Messrs. Burr, Parsons, Harrod and Grunsky, are civil engineers of the highest professional standing and of long experience on both the technical and the executive sides of important engineering works.

As we announced last week, Mr. John F. Wallace has now been selected to be Chief Engineer of the canal; and the profession will generally concur that the choice is an admirable one. There are very few men in the top rank of the profession who have proved both their ability as engineers, and also their executive ability and business ability by the discharge of large responsibilities in important positions as has Mr. Wallace.

With such a Commission and such a Chief Engineer, it goes without saying that efficiency and ability will be the standard in making up the great corps of engineers that will be required for the conduct of the work. It has in fact been announced that the merit system and civil service methods will be followed in making appointments.

All this means more to the engineering profession and to the people of the United States than is generally realized. We have escaped the danger that this great work might be turned over to a syndicate of capitalists to handle as they pleased, which means in such a manner as would yield them the largest profit on the sale of securities and the work of construction. We have escaped the danger that the enterprise might be made a political perquisite, so that engineers and contractors would have to seek political backing in order to secure and keep positions or contracts, and in escaping this we have escaped the dishonesty and fraud and loss that is its inevitable accompaniment.

And in escaping such evil conditions and in having the work at Panama started on the basis of honest and efficient administration, even more has been accomplished for American engineering than may at first sight appear. Not only are we assured that the greatest engineering work ever undertaken will be carried out on sound engineering principles but its successful accomplishment will give a greater international prestige to the work of American engineers and will create a demand for their services in many other parts of the world.

A lesson in the safe installation of storage batteries is furnished by the recent explosion on Mr. W. K. Vanderbilt's steam yacht, in which three men were injured. The cause appears to have been the accumulation of gas from storage batteries used for lighting the vessel at times when the generator was not running. The batteries were stowed in an inclosed space in the foreward hold and the gas which escaped from them was ignited by the fire in the cook's galley, causing an explosion which wrecked the forepart of the boat and set it on fire.

It is pretty well known that more or less gas is likely to escape from storage batteries, and that when mixed with air it forms an explosive as dangerous as gunpowder and liable to ignition by any stray spark from a match or cigar. But there is a general tendency to stow storage batteries in some out of the way place, which cannot be used for anything else, and where good ventilation is often very difficult. It ought to be realized that a storage battery is actually a gas generator, and that provision should always be made for the escape of the gas so that it cannot accumulate and mix with air in confined spaces.

The excellent suggestion is made in a brief paper recently read before the St. Paul Society of Civil Engineers* that some capable investigator ought to compile a history of the origin of the United States public land surveys. The author of the paper, Mr. W. A. Truesdell, himself presents much interesting material on the subject and shows that the division of the land into townships six miles square long antedated the work of Jared Mansfield, who was the second Surveyor-General of the United States, and who was credited by Prof. Davies with having originated the U. S. public land surveys. Mr. Truesdell says that Rufus Putnam, the first Surveyor-General, was really responsible for the adoption of the six-mile square township. In 1783, some 13 years before his appointment as Surveyor-General, Putnam was the prime mover in a petition to Congress by officers of the Revolutionary army asking that the lands be granted to these officers should be in one contiguous tract, between the Ohio River and Lake Erie, and that they should be granted "in townships six miles square." We quote as follows from Mr. Truesdell's paper:

> Mark the word township. This is considered by many people who know the facts to be the origin of the method which was afterward put in practice. It was the first suggestion ever made, or the first plan ever proposed, of which there is any record, for dividing the lands of the Northwest Territory according to a method which two years later was enacted into a law. That Putnam was the author of the idea there can be no doubt. He had been a land surveyor the greater portion of his life, and must have known from experience the advantages of dividing land in that manner over the old metes and bounds practice that had long prevailed in the colonies.
>
> It would be interesting to know why Putnam was so firmly committed to a 6-mile square township, for in his request for that standard he appears to be somewhat set in his opinion.

Continuing, Mr. Truesdell shows that the Continental Congress in 1785 appointed a committee to frame a law for the survey and subdivision of the wild lands of the West. Thomas Jefferson was chairman of that committee and the report favored the division of the territory into tracts 10 miles square to be called "hundreds" and these tracts into 100 square plots, each one mile square, to be called "lots." One detects here the influence of the current agitation for the decimal system, with which Jefferson would naturally be familiar, which later resulted in France in the establishment of the metric system and in this country in a decimal currency.

The act was amended before passage, however, to reduce the tracts to 7 miles square and later to 6 miles square, in which form it finally became a law. That Putnam exerted a large influence in the adoption of the six-mile square township is entirely probable; but the decision of Congress was doubtless influenced largely by the opinions and votes of the members from New England, all of whom must have been familiar with the six-mile square township. In fact if we wish to find the real origin of the six-mile square township, we must go back much further than 1785, and the adoption of this size of township will doubtless be found to be closely connected with the New England system of town government and even with the New England town meeting.

If one studies a map of the New England States on which the township boundaries are shown, he will find the townships in the regions of earliest settlement laid out with broken and irregular boundaries, the evident result of local circumstances and conditions in laying down dividing lines between the earliest groups of settlements. In those portions of Massachusetts and Connecticut which were settled at a later date, however, and still more in Vermont and New Hampshire, there is evident a systematic attempt to make townships as nearly square as possible and approximating 36 square miles in area. A large proportion of these towns still retain substantially the boundaries laid down by the first surveyors.

It seems altogether probable that this particular size was chosen with direct regard to the New England system of local town government, under which the inhabitants of each township formed a self-governing community. A larger sized township would have placed the outlying inhabitants inconveniently far from the center where the town meeting was held and the "meeting house" was located, particularly in the early days when roads and methods of transportation were primitive.

Not only can the six-mile square township be directly traced to New England, but the boundaries of New England towns show an evident attempt to follow north and south and east and west lines. This attempt was often frustrated by the rugged topography of New England, which made a mountain range or the course of a river a preferable guide instead of a meridian; but it is quite clear that had these same surveyors been set at work on the smooth prairies of the West, they would have laid out regular townships on very much the lines which Putnam and his successors followed in later years.

Engineers have not infrequently been justly criticised for their failure to obtain a pleasing appearance in their works, and it has been said that engineers as architects are, as a rule, unsuccessful. With equal truth may it be said that when the architect attempts engineering work which he is not competent to perform, the result is likely to be disastrous. An apt illustration is found in the story of the Abilene tank-tower, given in another column of this issue. There an architect undertook the design of a structure belonging strictly in the province of the engineer, and when the structure was built it collapsed before it could be put into service. The case is aggravated, or rather it is rendered a more precise illustration, by the fact that the architect was informed of the dangerous weakness of the design, but nevertheless ordered it to be carried out as drawn. Cases of similar nature, where failures have resulted from an architect undertaking engineering work without the aid of competent advice, are not altogether unknown. Each succeeding case should be emphasized as an additional reminder that engineering problems should be entrusted only to the trained engineer, and may not be undertaken by anyone at random, even though he be an architect.

The fact is that for a century past architecture and constructive engineering have been distinct fields, dovetailing together, it is true, but overlapping only very slightly. They have, moreover, separated more and more during this period. While in the earlier times they were identified in a common profession, to-day they have little in common. The work which was formerly done by the architect alone is now divided between the architect and the structural engineer. Dealing with the subject of building construction from wholly different points of view, they natu-

*Published in the "Journal of the Association of Engineering Societies" for April.

rally modify and supplement each other's work. The architect plans a structure for pleasing effect; the engineer proportions its parts for strength and for suitability with respect to natural conditions. The separation is most complete in such cases of building work as, for example, a large factory or an office building. In other cases it is less complete; thus in the case of a dwelling-house the architect takes upon himself the design of the entire building and details. But these latter cases must not blind us to the fact that architecture and engineering are totally distinct fields, and that each should be left to those who have made it a special study.

MAKING CONCRETE WATER TIGHT.

The increasing use of concrete for tanks and reservoirs and in various kinds of conduit and subway work, is attracting the attention of engineers to means for securing water-tight construction. There have come to us recently a number of inquiries as to how a water-tight or impermeable concrete might be secured. Generally the writer asked for some kind of efficient waterproofing, or else desired to know how this or the other kind of proposed waterproofing material would serve under stated conditions. These are very important questions, and by the same token they are very difficult questions to answer. The height of this difficulty is hardly appreciated in fact until one undertakes to seek and coordinate the knowledge that is available on the subject in technical literature. In view of this it may serve a good purpose to review briefly the means that have been employed to make concrete water tight.

Tightness against penetration by water is chiefly important in two classes of structures, those whose purpose it is to inclose a space which, to serve its purpose, must be kept dry, and those whose purpose it is to confine liquids. Subways for pipes and wires and underground railways belong to the first class defined, and tanks, aqueducts and sewers are the chief representatives of the second class. The degree to which tightness is a requisite of any of these structures depends upon the individual circumstances. In underground street railways it is essential not only that the penetration of water be avoided, but also that dampness should be prevented. For aqueducts it is usually not necessary to go further in securing tightness than to make sure that the leakage is not a calculable drain on the supply of water that passes through the conduit. These are the practical desiderata; practically, absolute tightness is only an ideal toward which the engineer aims. So long, therefore, as the engineer meets the practical requirements for water tightness in his works, he is doing all that good engineering requires. To strain for further perfection verges on dangerous ground if we define engineering as the art of making a dollar earn the most interest. This thought has been emphasized here because several recent discussions on water-tight concrete have shown a hypercritical spirit; because various prevailing methods of rendering concrete tight against water are not perfection, they are classed as useless. This conclusion is quite as vicious as would be the opposite conclusion that partial perfection is perfect enough.

Starting with the purpose merely of doing the best that is to be done, there are open to the designer and builder of concrete work two paths for reaching water-tight construction. The first is to employ some form of waterproofing, and the second is so to manufacture the concrete that it is impermeable. In actual practice less attention has been paid to developing impermeable mixtures of concrete than has been given to the use of waterproof coatings, probably because possible modes of solving the problem in the last-mentioned manner readily suggested themselves, while the searching out of an impermeable concrete mixture bade fair to be an intricate task. However this may have been, the fact persists that most attempts to secure water-tight concrete have been attempts at waterproofing.

The most common form of waterproofing has been some kind of asphalt coating used sometimes alone and sometimes in combination with tarred or asbestos felt. When felt and asphalt are combined, they are laid in alternate layers on a concrete bed and then are covered with the remainder of the concrete; the layer next the concrete in both cases being asphalt. There are generally from three to six layers of felt. Asphalt for this work is always the best grade of Bermudez or Alcatraz lake asphalt, and the felt is usually asbestos felt for points below ground-water level, and tarred felt for points above this level. This style of waterproofing has been extensively used in underground railway work in New York and other cities, and is generally regarded as being of unusually high quality. Its ultimate durability is unknown.

For ordinary work the asphalt coating is usually formed without felt, and consists either of asphalt alone or of asphalt mastic. When asphalt alone is used the concrete surface is first plastered with rich mortar on which the asphalt is mopped to a thickness of ⅛ in., and then plastered over before depositing the remainder of the concrete. Asphalt mastic is usually laid directly on the concrete and covered directly by the remainder of the concrete. The coat is usually about ½ in. thick. These forms of waterproofing have been much used in waterproofing gun enclosures and magazines in fortification work.*

The Government engineers have also successfully used a waterproofing wash composed of an alum and lye solution mixed with cement in the proportion of one pint of solution to five pounds of cement. The solution itself is composed of one pound of concentrated lye, five pounds of alum and two gallons of water. This wash is applied with a brush and well rubbed in. In this same category there may be included the so-called Sylvester wash and the water-glass washes so long familiar to engineers.

In Europe where many tanks and conduits have been built of reinforced concrete, the only waterproofing used is a layer of rich cement mortar coating about 1 in. thick. This mortar coating is preferably built up with the concrete and is placed on the inside. A cement grout wash applied with a brush, is the standard waterproof finish used in America in ordinary cement cistern work. For pressures of over 50 ft. head, the European manufacturers of reinforced cement pipe conduit consider that a sheet steel lining is necessary in order to make the pipe water tight. These cast pipes have very thin shells, however, and for heavier conduit the only precaution taken is to use a wet mixture and make the inside layer of mortar. Recently in America the practice in waterproofing the arch ring and spandrel walls of arch bridges, has been to give them a plaster coat of rich cement mortar. For tank and conduit work, generally, experience in both Europe and America indicates that all practical requirements for water tightness are secured by a wet mixture and a cement mortar coating.

Turning now to the possibilities of making concrete impermeable, we find that a number of experiments have been made on impermeable concretes, both in Europe and America. In these experiments the object sought has been either the determination of a mixture of cement and aggregates that would resist the percolation of water or the discovery of a substance which by admixture with the concrete materials would render the hardened product impermeable.

The elaborate tests of Mr. R. Feret, of the Boulogne Laboratory of the Ponts et Chaussees, extending over five years, led him to the following conclusions:

> That in all mortars of granulometric composition, the most permeable are those which contain the least quantity of cement.
>
> Of all mortars of the same richness, but of varying granulometric composition, those which contain very few fine grains are much more permeable. They are the more so where, with equal proportions of the fine grain, the coarse grains predominate more in relation to the grains of medium size.
>
> The minimum permeability is found in mortars where the proportion of medium size grains is small, and the coarse and fine grains are about equal to each other.

Mr. Feret's experiments also showed that the permeability of mortars submitted to a continuous filtration of fresh water or sea water diminishes rapidly with time. He also recommends using a too large rather than a too small quantity of mixing water.

A series of experiments made by Mr. G. W. Hyde and W. J. Smith, in 1889, on the permeability of mortars and concretes, showed that with the same proportions of cement, mortars made with fine sand are less permeable than those made with coarse sand; that with the same quality of sand, permeability increases as the proportion of cement increases; that mortar made with good cement is less permeable than any cement and sand mortar.

A third set of tests to determine the permeability of concrete under high water pressures, show results which are in general similar to those already stated. These tests were made by Mr. J. B. McIntyre and A. L. True at the Thayer School of Civil Engineering in 1902, using 1-1, 1-2 and 1-3 Portland cement and sand mortars. The conclusions drawn from these experiments were as follows:

> From the tables it will be seen that several of the mixtures were practically impermeable to water at the pressures which we had at our disposal, nearly from 20 to 80 lbs. per sq. in.
>
> All the specimens composed of 1:1 mortar in the proportion of 30, 35, 40 and 45% of the whole mass were impermeable. Some of the specimens composed 1:2 mortar in the proportions of 40 and 45% were also impermeable, as well as the mixtures of 1:2:4 and 1:2½:4.
>
> All others leaked at the high pressure, and in a general way may be said to have shown a degree of imperviousness in direct proportion to the proportion of mortar in them, with the lower pressures, as well as with 80 lbs.

In a number of instances it has been found that water percolating through concrete absorbed lime in its passage which was deposited on the exterior surface of the concrete in the form of an efflorescence that acted as a very perfect seal against further percolation. These experiences have been taken by a number of engineers as the basis for a theory that slacked lime added to the concrete mixture would serve to make it impermeable. Mr. R. W. Lesley, Assoc. Am. Soc. C. E., advocated this practice in a discussion before the American Society of Civil Engineers in the following words:

> The speaker's theory and conclusions, based upon all that has been discovered, and especially upon Feret's remarkable experiments, would seem to indicate that the best addition to cement mortars for the purpose of making them impermeable, according to the theory of an exterior coating by lime carried through the mass during filtration, would be to add to the concrete, at the time of mixing, a reasonable proportion of hydrate of lime, or, in other words, the ordinary slaked lime of commerce. This slaked lime, as has been shown by experiments of the late Professor De Smedt, formerly of the Laboratory of the District of Columbia, does not injure cements or mortars; does not cause expansion; and does not decrease their strength, though retarding their setting slightly. Such an addition would be perfectly safe, as a matter of practice, and would form in the mass a substance which would be carried by filtration and close the pores, form efflorescence or stalactites and stalagmites on the surface, and, in the speaker's judgment, though he knows of no experiments on the subject, would aid largely in making mortars impermeable. Experiments in this line would be most valuable.

Other substances which have been mixed with the concrete materials to render the hardened product impermeable to water are silicate of soda or water glass and soap and alum. Experiments conducted by Prof. W. K. Hatt to determine the effect of these substances on concrete, gave the following results:

> The effect of silicate of soda is to diminish the strength of both ash and sand mortars more than 50%, and to diminish the absorption of the ash mortars about 50%. The effect of alum and soap mixed in with the mortar at the time it is gaged is to strengthen and harden the ash mortar about 50% and to diminish its absorption by 50%. A soap solution alone will diminish the absorption (by the action of the alkali in the cement on the soap) but will not increase the strength. The strength of the sand mortar is not greatly affected by the soap and alum, but its absorption is decreased about 50%. The effect on the absorption was measured by comparison of the weight of water taken up by briquettes which were immersed after having been dried out. Check tests were made by measuring the water which percolated from the outside through the walls of hollow cylinders. The speaker believes that this is the first use of a soap and alum solution for waterproofing, in place of the usual gaging water. The method used by the speaker is as follows: A 5% solution of ground alum and water is prepared; and a 7% solution of soap and water. The alum solution is mixed with the mortar to the amount of one-half the ordinary gaging water. The soap solution is then applied in amount to bring the mortar to the desired plasticity. The soap and alum, acting together, cause the precipitation of an insoluble compound in the pores of the mortar.

The neatest solution of the problem of securing water-tight concrete work is without doubt to use a concrete which is itself impermeable instead of resorting to waterproof coatings. This should be the end to which students of the subject should direct their efforts. At the present time our knowledge of impermeable mixtures is too limited to warrant definite recommendations for all con-

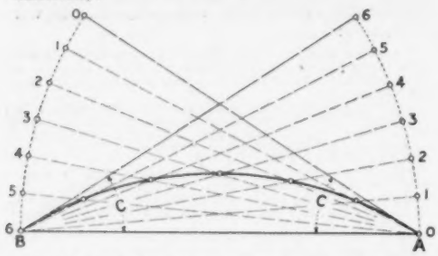
*Specifications for work of this kind will be found in Engineering News of April 2, 1903.

ditions. It seems quite certain, however, that engineers will accomplish all that practical requirements necessitate in the great bulk of concrete work where percolation and leakage are to be avoided if they use a moderately rich concrete, mixed wet and coated on one or both faces with a thickness of mortar.

LETTERS TO THE EDITOR.

A Neat Method of Plotting a Curve of Large Radius.

Sir: The recent publication of several methods of drawing the parabola leads me to send you this note on the circle. Experience in the drawing-room shows that draftsmen are often puzzled as to the means of drawing a circular arc of radius too large for the beam compass or a "railroad" curve. The following method has proven satisfactory:



Let A B be a chord of the required arc. At each end of this draw a tangent, the angle C being computed from the formula $\sin C = \frac{\frac{1}{2}\text{ chord}}{\text{Radius}}$; from A and B as centers draw arcs BO and AG, intersecting the tangents; divide these arcs into any number of equal parts and number them in reverse order, as shown; draw the series of radial lines from A and B. The intersection of A1 with B1 will give a point on the required arc, as will also that of A2 with B2, and so on for the other pairs of radii. A spline or a steel straight-edge (placed edgewise to the paper) may then be sprung so as to pass through the points, and the curve drawn along the edge.

Very truly yours, Frank T. Daniels.

No. 1 Ashburton Place, Boston, Mass., May 3, 1904.

Patents on Parabolic Suspension Coal Bins.

Sir: Referring to the article entitled "Modern Methods of Handling Iron Ore," by Mr. Charles H. Wright, M. Am. Soc. C. E., in your issue of May 5, and particularly to page 435, first column, there is mentioned the parabolic suspension type of bin as being the latest, most economical and satisfactory form of bin in use, etc. The bin referred to in this article is, as near as I can see, the same one that was patented by me in 1899, the patent bearing the serial number of 625,947 and the construction being described in Engineering News of July 7, 1899.

The public should be informed that this is a patented type of construction both for its own protection and also to comply with the patent laws.

Yours very truly, A. Samuel Berquist,

Civil Engineer and Inventor of the Suspended Type of Bin.

Brooklyn, N. Y., May 7, 1904.

(Proof of the above letter was referred to the author of the paper on Ore Handling, and we append his reply as follows.—Ed.)

Sir: I have your note of May 10, submitting a proof copy of a letter you have received from A. Samuel Berquist under date of May 7. The bin described in my article, to which he alludes, belongs to a type of ore and coal constructions distinctly set out in a patent granted Mr. Alexander E. Brown as far back as 1887, and the patent subsequently granted to Mr. Berquist, so far as I can judge, is without merit of invention, nor does it embrace any features that are new, so far as Mr. Berquist is concerned. Knowing what had been done in the art before he came on the scene, it is strange to engineers that he can take the position he does in his letter sent you for publication. Yours truly,

Chas. H. Wright.

Cleveland, Ohio, May 12, 1904.

The Theory of Momentum Grades.

Sir: In the article by Prof. Taylor in your issue of April 28, I am quoted and I think criticized for an early paper in "The Railroad Gazette," where the treatment of "Momentum Grades" was taken up by me on a straight line basis. There is a fair chance that, by intelligent handling of grades adopted in the treatment shown there, results may be obtained as good as one could expect from any method when the pull of the locomotive, and the train resistance both vary with speed and neither can be predicted for a given velocity within rather wide limits.

Nevertheless, I wish to say that I have long since outgrown this method of treatment in favor of that of a curved line diagram, the method of Mr. Dennis in Engineering News, Nov. 22, 1900, as quoted by Prof. Taylor, and which is also the method of Mr. Dennis in his paper before the American Society of Civil Engineers. This method was elaborated somewhat in the Proceedings of the American Railway Engineering and Maintenance of Way Association for 1902. The report of the Committee on Roadway, which presented this method of treatment was signed by myself as one of the members of that committee which establishes my position in the matter early in 1902. Prof. Taylor was present at the meeting at which this report was presented, but evidently failed to keep the report in mind in enumerating the various articles where the subject had been treated in a proper way. The report was quoted in the "Railroad Gazette," "Railway Age," "Railway Review," and Engineering News of date March or April, 1902. Prof. Taylor seems to have missed this article.

As a matter of fact, while there are no text books covering the subject in this way, it has been my privilege and pleasure to teach this method to my classes for several years. I have taught it to four different classes in the last three or four years. C. Frank Allen.

Massachusetts Institute of Technology, Boston, May 11, 1904.

Limestone Screenings for Cement Sidewalks.

Sir: I would like to add a few suggestions to your article in Engineering News of April 28, 1904, in which you discuss the use of limestone screenings in the cement sidewalks of the city of Chicago.

It seems to me that the mayor was both right and wrong in not allowing their use; right in not allowing their use in the wearing surface, and wrong in not allowing their use in the concrete base on which the mortar to form the wearing surface is spread. There is but one other artificial sand that will make a stronger mortar than crushed limestone, and that is crushed trap rock. The reason for this is that trap rock breaks up in more irregular grains, with rougher surfaces than any other stone, and thus gives the cement a greater grip. But while the limestone sand gives greater strength than any natural sand, and is therefore much better for concrete it is not as good as natural sand in the surface of the sidewalk, simply because it will not wear as long as sand; and it is the resistance to wear that determines the life of a sidewalk, especially in a city with such heavy travel as Chicago.

A walk with a surface of neat cement is not as durable as one with a mortar of one cement to one sand, because the cement is not as hard as the sand; and a mortar of one cement to one sand is not as durable as one of one cement to two sand, because in the former case the voids are more than filled and some of the cement forms part of the wearing surface, and will therefore wear out quicker than the mortar which has a complete wearing surface of sand. The strength is derived from the concrete below, and the life of the walk is entirely dependent upon the hardness of the surface. The most durable sidewalks are made from crushed trap rock, using the small rock for concrete, and the finer particles with the dust screened out, as sand for the mortar. This is not only the strongest mortar and concrete that can be obtained, but also makes a very hard surface, that will resist wear better than any other sand. In making the mortar for the wearing surface the writer would advise the use of a large percentage of coarse sand, say 50%, held on a 20-mesh sieve. Yours respectfully,

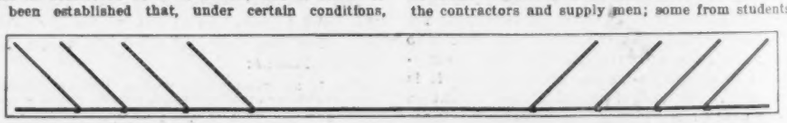
A. S. Cooper,

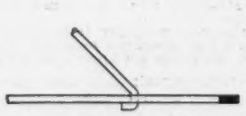
U. S. Assistant Engineer.

Savannah, Ga., May 21, 1904.

A Proposed Method of Reinforcement Against Shear in Concrete-Steel Girders.

Sir: Much has recently been written upon shearing stresses in reinforced concrete beams, and it seems to have been established that, under certain conditions, shear-bars must be provided to assist the concrete in causing stress to accumulate in the tension reinforcement. It has been argued that these shear-bars should be attached directly to the tension reinforcement and this seems desirable; for, if the shear-bars are intended to relieve the concrete, the stress in them should not be again transmitted through the concrete at their lower ends in order to reach the tension reinforcement.





A SUGGESTED REINFORCEMENT TO TAKE SHEAR IN CONCRETE-STEEL GIRDERS.

A number of "systems" (details would be the less pretentious word used in steelwork) have been designed with the above ideas in mind, and the writer submits herewith a sketch of a detail that he believes will accomplish the purpose. Flat bars are used as tension reinforcement and for some distance from each end holes are punched through them at suitable intervals and of suitable size. Through these holes bars are put which have been bent at their lower end as indicated in the sketch. Thus the size and distribution of the shear-bars are under the control of the designer.

The gross area of the tension reinforcement is available at the point of greatest bending moment, and the section would probably not have to be reduced by holes until a place shall have been reached at which the net section would suffice. Much of this, however, depends on the skill of the designer. An objection which may be urged is that there is at the ends of the tension reinforcement a waste of metal; but this waste is no greater than is ordinarily found in riveted steelwork. This objection does not apply to some of the "systems" now extant.

The details of practice must, of course, be determined by experiment and by experience; the writer believes, however, that these shear-bars, if made of "rivet steel," could be bent cold without injury.

Various possible modifications of course suggest themselves. The shear-bars might be upset at their lower end so as to resemble a rivet head, or they might be threaded and provided with a nut. Again, they might be bent or split at their upper ends to prevent their slipping through the concrete. The tension reinforcement might be set on edge and the shear-bars might either be hooked or formed into U's passing through the tension bars.

To the writer's knowledge, this detail has not been previously suggested; and it is this, as well as the belief that it is not covered by patents, that causes him to submit it for discussion. Respectfully,

Hans C. Toensfeldt, Jun. Am. Soc. C. E.

1009 Fullerton Bldg., St. Louis, Mo., April 21, 1904

Concerning the Basis for Engineers' Fees.

Sir: In Engineering News of April 28 there appears an article concerning professional fees, and the suggestion that engineers should boldly announce their charges is certainly an excellent idea, and one that would lead to the ultimate benefit of the profession if adopted and conscientiously followed by its leading members.

This article opens the way for discussion as to what should be the proper charge for professional services of an engineer, and the writer would greatly enjoy hearing expressions of opinion from others on this subject.

In this connection, a recent experience of the writer may be of interest. He was asked by the officials of a small city to submit his terms for the engineering work on a proposed water-works system to cost $23,000. He did so, and his terms for the surveys, plans and specifications, together with supervision, amounted to 5¼% of the cost of the proposed works. In due course of time he was advised by the Mayor that the Council had investigated his references and found them unexcelled, but that they had received terms from 20 other engineers whose prices ranged from $100 for plans and specifications up to the writer's terms, and inasmuch as none of the other 19 exceeded $800, the Council considered the writer's terms exorbitant, but the Mayor added the consolation that had the writer's price been within $200 of the others the Council would have given him that much preference on account of his excellent work in neighboring cities. The work was given to an engineer with excellent references, showing him to have had 18 years' experience, whose terms for the complete work were $437, or 1.9% of the cost of construction.

Now, it is to be expected that many of the twenty propositions received by the Council would be from contractors with other axes to grind; some from dishonest so-called engineers, who will extort commissions from the contractors and supply men; some from students anxious for a summer's employment; and some perhaps from young engineers just beginning their career as proprietors of an office. The prices of all such as these would be expected to be merely nominal; for if a contractor secures a job of engineering work he will be cared for by his fellow contractors; if an unscrupulous "engineer" secures the work there stands a herd of supply men at his side, who are ready to divide commissions with him, or rather add on an extra commission for his special benefit; if a student can put in his summer at $150 per month on such

work he usually accepts the opportunity for he has no reputation at stake and assumes no responsibility; again, it is not surprising that a young engineer just making a start in life should offer to do professional work at a figure low enough to secure the work, for this is only in accordance with sound political economy, and as soon as he has to his credit a good record to which to point, he can raise the terms to approach more and more nearly the fees charged by those members of the profession who are recognized leaders.

What can be said, however, of an engineer of 18 years' experience, having won excellent references, who offers to do engineering work at less than 2%? When a young engineer meets such experiences as this, what encouragement has he to endeavor to raise his prices at all? To those of experience in business ventures it is evident that there must be some economic reason why any one will do work at such prices, and this reason may be safely surmised.

It is sincerely hoped that other practicing engineers will offer some discussion bearing upon the question of proper fees for professional services.

Respectfully, Practitioner.

Missouri, May 3, 1904.

Concerning the Vacuum Under the Crest of Overtopped Dams.

Sir: I note your editorial reply to my inquiry, relative to data in regard to the existence of a vacuum, or partial vacuum between the face of overtopped dams and the sheet of overflowing water, printed on page 450 of Engineering News of May 12, 1904.

The observation of Mr. Knight quoted by you, while interesting, is not very definite or satisfactory.

As I remarked, the theory of the existence of an air pressure below the normal, in such dams, seems reasonable, but if it rests on no better experimental data than you are able to refer to, engineers are hardly justified in discussing the phenomenon so seriously or learnedly, as some have essayed to do. It is hardly logical to attribute the failure of dams to a cause, the magnitude of which, or even the existence of which, has not been satisfactorily established.

It would seem to be a comparatively simple matter, at some one of the existing hydraulic laboratories, to connect the cavity between the face of a dam and the overflowing sheet of water with a barometer, and thus settle the question of the existence of air pressure below the normal, and its intensity. A series of such experiments under different conditions of height of dam and head of overflow would yield more valuable data upon the subject than any amount of theory unsupported by such experiments.

It is to be hoped that some of the laboratories will take the matter up as early as possible.

Yours truly, Engineer.

New York, May 16, 1904.

Sir: The discussion in your columns about the vacuum under a sheet of water falling over a dam is interesting, not only as a natural phenomenon, but because it shows a lack of familiarity with an important engineering subject. About ten years ago, while replacing the foundations of a drawbridge near Poughkeepsie, I had occasion to go to Wappinger's Falls, and was greatly surprised and mystified to see the glass fronts of all the stores in a state of intense vibration. The local surveyor explained the phenomenon by calling my attention to a small dam not far away over the crest of which a heavy sheet of water was falling. He said that when the dam was first built there was great annoyance because of these vibrations and that their cause was wholly unknown until a traveling clock repairer came to town and showed that by building small cribs at intervals along the crest of the dam the water sheet was parted and the vibrations ceased. At the time of my visit the dam had recently been repaired and the little cribs had not been replaced. At a later date when again in the town there was no water falling over the dam and there were no vibrations.

The statement was made at the time of my first visit that the vibrations had been sufficient to cause plastering to fall from ceilings a mile from the dam. While this statement seemed rather hard to believe, it was told in good faith and may have been true.

Upon looking up the subject I found that the matter was fully explained in "Trautwine's Pocket Book." The vibrations were caused by vibrations of the sheet of water which in their turn were due to the changes of air pressure between the water and the face of the dam.

Engineers who are too busy to do any reading are quite likely to repeat the mistakes of others although they have been fully discussed in the periodicals, and this may be a reason why the man who styles himself a practical engineer hesitates to employ a man to do work a little out of his usual practice. Such men are prone to belittle any knowledge gained from literature, even though well supported by abundant engineering experience, and I would use the discussion to point out the value of a wide range of reading, to both the reader and the one seeking engineering advice. Yours truly,

Albert J. Himes.

521 Hickox Building, Cleveland, O., May 16, 1904.

Notes and Queries.

In publishing the description of the unique skew bridge at Lawrence, Mass., in our last week's issue, we omitted to give credit to Mr. F. M. Goodhue, who first brought the structure to our attention as a novel and creditable example of bridge designing.

Apropos of the recent discussion on the use of the letters C. E. or M. E., a San Francisco correspondent suggests that:

In placing C. E. after his name an engineer should add the initials of the college of which he is a graduate and the year in which he received his degree. For example: John Smith is a graduate of the University of California and received his degree during the year 1893, and if he were to write his name according to the above plan it would read as follows: "John Smith, C. E., U. C., '93." Most men are proud of their "alma mater" and the placing it after their name each time they wrote it might prove an incentive for better and harder work. Also, if the universities were to see that they must stand personally responsible for each degree they awarded they would undoubtedly be more careful how and to whom they gave them.

It is not at all uncommon for an engineer in advertising for a position to state that he graduated from an engineering school in such a year, and if the school is one of wide reputation he will usually state the name of the school. But to habitually write C. E., R. P. I., '00, after one's name, for example, would be in doubtful taste, and as the years go on the graduate is apt to drop altogether the idea that the four years of his professional education constitute any recommendation to his clients or employers in comparison with the experience which he has accumulated in later years.

THE ELECTRIC HEADLIGHT AS A SAFETY APPLIANCE.*

By J. A. Carney.†

The electric headlight as an adjunct to modern railway practice has a great many advantages and some deficiencies. As a warning to the public who may have occasion to cross the right of way at grade, its value is almost without estimate. Some years ago a railway running through a prairie state put on a high-speed train leaving a terminal about 9.30 p. m. Electric headlights were not used at the time of its installation and there were a number of highway crossing accidents. The engines running the trains were afterwards equipped with electric headlights and the crossing accidents stopped. A man approaching a railway crossing and hearing the whistle would say to himself, "Freight, plenty of time," and get on the track about the same time the engine reached the crossing. The electric headlight is a warning to the public that a high-speed train is approaching and they exercise more care.

An electric headlight burning in a switching yard is a nuisance, and it almost obliterates hand lanterns and switch lights that come in its field, and at many division points it is the rule to shut down the light while the engine is waiting for its train.

The diseases of the electric headlight are many. It is the purpose of this paper, however, to touch on one only, namely, the effect of the diverging rays of light on the vision of the engine man during snow, rain or mist, so far as being able to see signals at a safe distance. Heavy snow and rain do render signal lights invisible, except at short distances, and it is needless to describe the effect of fog, but where these elements are of such quantity that they do not obscure signals at safe distances is where the electric headlight does the most harm. The diverging rays light up the particles of rain and snow or mist and produce a curtain of light which it is almost impossible to see through.

An endeavor to alleviate this difficulty has been made by fitting a cylindrical extension about 15 ins. long to the ordinary headlight. This headlight is in service and gives a sharper pencil of light and seems to illuminate the track better than does the standard case. Since this form of case has been in service there has been no opportunity to test its merits in mist or snow, but observations made in a light rain storm testify in its favor.

As a warning to persons on the track there is no difference in the effectiveness of the two forms of cases, and at a distance of half a mile it is impossible to tell one from the other by the volume of light thrown out.

*Abstract of a paper read at the May meeting of the Western Railway Club, Chicago.

†Master Mechanic, Chicago, Burlington & Quincy Ry., West Burlington, Ia.

A REMARKABLY ELASTIC PIECE OF STONE.

The bent plate in the accompanying photograph is not a piece of wood or metal, but a piece of stone. The photograph is sent to us by Mr. C. H. Burgess, of Cleveland, O., who states that the material is locally known as Euclid bluestone, and is geologically an indurated Erie shale containing about 95% of silica. It is very fine in grain and works very slowly with either saw or chisel. The thin slab in the photograph was, of course, cut with a saw. It was, Mr. Burgess states, 6½ ft. in length, 6 ins. wide, and a trifle over ¼ of an inch thick. Supported on two bricks each 4 ins. high, the scale showed a deflection at the center of 5¼ ins. The entire weight of the slab was 13 1-10 lbs., and the supported weights near the center amounted to 3½ lbs. The slab was practically straight when placed on the supports, and broke while under the exposure of the camera.

A Transverse Test of a Stone Slab.

The task of computing the modulus of rupture and modulus of elasticity of the stone will be an excellent problem for some of our student readers. The photograph is of interest as a concrete illustration of the fact not always remembered by even the most experienced engineers that all materials, even those often classed as unyielding, are actually elastic under stress.

We may add that the stone has a specific gravity of about 2.45, or a weight of something over 150 lbs. per cu. ft., and the test shows it to possess remarkable homogeneity.

THE LARGEST APPROPRIATION FOR GOOD ROADS ever made by any state for expenditure in one year has just been made by the state of New York, the bill having been signed by the Governor. The sum appropriated is $1,500,000, which, under the New York state law, means that $3,000,000 will be expended this year in building macadam and gravel roads. Contracts for at least 350 miles of improved highways will probably be advertised for letting in the near future.

THE DAMAGE DONE BY THE COTTON BOLL WEEVIL in 1903 is estimated at about $50,000,000 by the Department of Agriculture. Scientific investigators gave warning of the progress of the insect which had they been heeded and acted upon might have enabled the spread of the insect from Mexico northward to be stopped. At present there appears no prospect that its spread can be checked except by the development of some form of natural enemy which will retard its increase.

STEEL AXLES.*

By J. L. Replogle.†

The comparative merits of steel and iron for car axles is a question which has engrossed the attention of railway officials and axle makers for many years. We feel justified in saying that the experience of these years has demonstrated that steel is superior to iron for this purpose, not only on account of its greater power of resistance against the shocks and vibrations to which it is subjected in service, but also on account of its greater wearing properties, the friction being less than in the iron axle, where lack of sufficient heat, presence of scale, or other conditions often prevent perfect adhesion of the various constituent parts. Even a perfectly welded iron axle will not allow the high polish and minimum amount of friction obtainable in the steel axle of the proper composition.

METHOD OF MANUFACTURE.

In the early days of steel axles, the steel maker had difficulty in proving the superiority of his product, as there were numerous breakages in service for which he could not account, his chemical analysis indicating that the elements were of the proper proportion to the evident requirements of the purpose. In looking for the cause, he found that while his light hammer of probably 2,000 lbs. falling weight was sufficiently powerful for building up iron bars probably one to two inches thick into an axle of approximately 5½ ins. diameter, it was entirely inadequate for forging steel axles, as steel, not possessing the welding properties of iron, could not be forged in the same manner. Instead of building up from bars one to two inches thick, he was compelled to reverse the method, and hammer down from a billet about twice the size his finished forging should be.

His hammer not being sufficiently powerful to penetrate throughout the mass, did not give the axle that homogeneous structure so essential in a forging subject to the heavy alternating stresses which a car axle undergoes in service. The internal condition of his axle was revealed

*Extracts from a paper read before the Western Railway Club, Chicago, May 17.

†Superintendent of Forge and Axle Department, Cambria Steel Co.

to him by the end of his rough forging, which was a deep concave, showing that the surface metal only had expanded and that the inner portion had not received the proper working and consequent homogeneity of structure which he desired. It also showed inclination to "pipe."

He appreciated his position and promptly strengthened it by the installation of heavier hammers of about three times the weight formerly used. While he immediately saw a distinct improvement in his forging (the end now being convex, indicating that the inner portion had received proper attention), the steel axle did not give the absolute satisfaction of which he thought it capable, and an investigation proved to him that heat treatment in the forge was largely responsible. He reasoned that as no two parts of the axle were forged at the same temperature, internal strains had set in, which were very detrimental to the forging, and which would have to be relieved. This was particularly evident in locomotive driving axles, which, after cutting key-way, thereby relieving strains in the fibers, would often become distorted.

To relieve the injurious strains above stated, he resorted to annealing. By heating the forging to a temperature slightly above the recalescent point (which, in steel of carbon usually found in axles, would be approximately 1,200° F.), he eliminated all crystallization resultant from the cooling from the forging temperature of about 1,800° F. and a fine amorphous structure was obtained. Crystallization would of course set in again when forging was being cooled, but as in the annealing he did not approach within 400° or 500° the temperature at which his axle was forged, the resultant crystallization was comparatively small. While the ductility of the annealed forging was greatly increased, it suffered a slight loss in elasticity.

Realizing the importance of having a high degree of elasticity in his material, which was continually subjected to severe alternating tension and compression, and often torsional strains, the axle maker started to experiment, with a view of not only maintaining the elasticity found in the original forging before annealing, but also to increase it.

Various methods have been used to gain this result, among the more prominent being the Coffin toughening process and oil tempering and annealing, either of which gives the following results: (1) The elastic limit is increased to a marked degree. (2) The percentage of elongation and reduction of area are greatly increased. (3) A remarkable degree of toughness is obtained. (4) Steel changes from a crystalline to an amorphous state. (5) Internal stresses are eliminated. (6) Uniformity of structure and strength are obtained. The increase in elasticity is of the greatest possible benefit as it is a recognized fact that once the elastic limit of metal has been passed and forging therefore distorted, it cannot be depended upon to sustain even minor loads.

In wrought iron forgings the elastic limit probably does not exceed 20,000 lbs. per sq. in. Steel of say .45 carbon, properly treated, will show almost three times as much elasticity and is, therefore, much better fitted for the service described.

SPECIFICATIONS.

Our opinion as to the best specification would be an endorsement of the present Master Car Builders' specification, with a few exceptions, viz.:

(1) We would recommend an increase in carbon, making the limit 0.40% to 0.50% instead of 0.35% to 0.50% as at present. This would insure greater wear, permitting a higher polish with a consequent reduction of friction, and, if properly treated, greater strength, but would necessitate a slight modification of the present drop test.

(2) We should insist upon all axles being thoroughly annealed, as by this method only, is the true strength of the steel represented.

(3) We would adopt a "maximum weight" clause compelling manufacturers to rough turn forgings on journals and wheel seats to within ⅛-in. of your finishing dimensions, thereby eliminating the necessity of
for 50 to 75 lbs. of excess material per axle, which also necessitates a vast amount of extra work and expense at the railway shops, subjecting your lathes to both roughing and finishing duties, which is detrimental to the best results in fitting.

(4) We should recommend a maximum limit on phosphorus of 0.05% instead of 0.07% as at present, to compensate for the recommended raise of the carbon limit by five points, both elements being hardeners, but carbon affecting the ductility less than the phosphorus, and being conducive to greater wearing qualities.

(5) We would modify that portion of the specification relating to the rough turning of axles to read: "Axles must be rough turned on journals and wheel fits to within ⅛-in. of finished dimensions and must be smooth forged between wheel fits." Rough turning a car axle between wheel fits robs the axle of the tough surface skin which is a very valuable asset.

In this connection, I would cite results of a test made at our works to demonstrate our claim: During a controversy with an inspector of a prominent railroad which specifies rough turning all over, we suggested to him that he take two axles of the same heat, one being rough turned to 5⅛ ins. in center, the other being smooth forged to same dimension. These axles were subjected to same treatment throughout and were then tested to breakage. The rough turned axle stood 21 blows of a 1,640-lb. drop from 43 ft. height, and the smooth forged one stood 78 blows, or almost four times as severe a test. Tensile tests cut from the broken axles showed the same chemical and physical structure.

Extensive tests made at another works by one of the leading railroads specifying this, show that in axles of the averege carbon, the smooth forged axle will stand approximately 43% harder test than the rough turned one. Rough turning an axle also makes it more susceptible to rust.

RECENT METHODS OF HYDROGRAPHIC SURVEYING.

By A. S. Cooper.*

As there have been several important developments in hydrographical surveying in this district recently, a description of some of them may be of interest to the readers of Engineering News.

The cheapest method of making such surveys where rough work will suffice, is by stadia readings for distances and compass readings for azimuths; making sketches between points and spacing in the soundings with the eye on the sketch. Very rapid work can be done by this method; and when only a general idea of the river is desired, it answers very well. The writer has averaged as much as 7½ miles a day for a whole month working in this manner.

If a little more accuracy is required, and an expenditure of about seven times as much is permissible, a modification of this method could be used. The sights should be shortened between stations and so selected that cross lines could be run from them; and instead of compass readings, the azimuth should be taken with the vernier of the transit, referring all readings to a fixed zero line, preferably the magnetic north, if the true meridian is not available. This makes back sights necessary, in order to carry the assumed azimuth forward on the survey. By spacing the cross lines about 100 ft., one mile a day of this class of work can be done on a river 600 ft. to 800 ft. wide. Where the banks are such as to permit, a greater accuracy can be secured by measuring a meander line down one or both banks of the river with a steel tape or band chain.

Sounding Boat Used on Hydrographic Surveys in the Savannah District.

Where very accurate work is required, however, the best mode of procedure in nearly all cases is by measuring a base line and developing a complete system of triangulation all over the territory to be covered. When the stations are once located, the sounding becomes a matter of detail work on which a greater or less amount of time and money can be spent, depending on the purpose for which the soundings are required. In nearly all cases the general method of two transits so placed as to give good intersections over the area to be sounded has been used in this district, and if handled with proper judgment the work can be done just as quickly as by using sextants, and is much more accurate and reliable.

Suppose the object of the survey is to determine the amount of material removed from a given area by a dredge, for payment to a contractor. In this case two lines of stakes are set parallel to each other on the same side of the river and a sufficient distance apart, usually about 500 ft., to give sensitive ranges across the area to be dredged, and so arranged that the cross lines will be at right angles to the line of dredging. Forty feet makes a very satisfactory spacing for these cross lines in ordinary material. The transit stations should be so placed as to give good intersections over the whole area, or if too large to be covered by two stations, several should be used, placing them all on the same side of the river, so that after the first two have been used the upper transit can be shifted down the river one station beyond the other instrument; and so on until the entire area is covered. The boat used for sounding is a 40-ft. steam launch, equipped with a compound engine, upright boiler, a signal mast, and a right and left sounding platform, each about 6 ft. from the signal mast. Two leadsmen, a recorder signalman, engineer and wheelman are required on the boat. The two transitmen, gage reader and two flagmen are first put in position, the two latter on the two-range stakes numbered 1. The steamer is then put in position a little beyond the area to be dredged, and with the mast exactly on line with these two flags, and held there until the second hand of the recorder's watch indicates some even minute, he having ordered the signal man to hoist the signal balloon 10 seconds before. The boat is then started across on this line at a speed of about 75 ft. per minute, the recorder at the same time ordering the right-hand leadsman to sound by calling "lead." When the lead becomes vertical the signalman drops the balloon, thus telling the two transitmen to sight on the mast at the instant the signal begins to fall. When the recorder's watch indicates 10 seconds he calls "lead" again, and the left-hand leadsman sounds; at 20 seconds the right-hand leadsman sounds again; at 30 seconds the left-hand leadsman; at 40 seconds the right-hand leadsman; at 50 seconds, in addition to calling "lead," the recorder calls "up," for the signalman to hoist the balloon; at 60 seconds, or on the next even minute, the right-hand leadsman sounds, and as the lead becomes vertical the balloon is again dropped for a location. This process is carried on until the line is run all the way across the area to be covered, when one long blast of a steam whistle is blown to warn the flagman to move up to range No. 2. By this method 6 accurately spaced soundings can be taken per minute in depths ranging from 20 to 35 ft. A greater number can be taken if the water is shoaler, and the number must be reduced if a greater depth than 35 ft. is to be encountered. After the dredging is completed these same lines should be re-run in the same manner, so that each cross-section can be platted under the corresponding ones taken before dredging on cross-section paper, and the area between the two lines gone over with a planimeter. This area multiplied by the distance between sections represents the amount of material removed by the dredge.

This same method is equally well adapted to rough and rapid examination surveys. In this case the speed of the boat should be increased and the lines spaced by the eye instead of using two flags on located range stakes. The writer recently surveyed an area two miles long and about 700 ft wide in one day by this method, besides going 15 miles each way to and from work. In this case if two sextants had been used it would have been an impossibility to cover the ground in that time.

In the writer's opinion the method described in Engineering News of March 26, 1903, and previously published in the Chief of Engineers' Report of 1902, page 2512, as devised by Mr. Bacon, does not compare at all favorably, either as to speed or accuracy, to the method here described. Even in places where several surveys are wanted over the same area, the two-transit method can be applied in exactly the same manner as the two sextants. A double protractor could be made on a sheet of drawing paper of sufficient size to cover the pro-

*U. S. Assistant Engineer, Savannah, Ga.

posed area on the desired scale, and positions platted where the two angle lines intersect, in exactly the same manner as was done by Mr. Bacon, except that in this case all angle lines will be straight lines instead of circles. In case permanent ranges are established, they could also be projected on this protractor, and only one transit used; although the writer does not approve of the use of only one instrument.

The sextant may be a useful instrument for rough examinations in covering large areas of

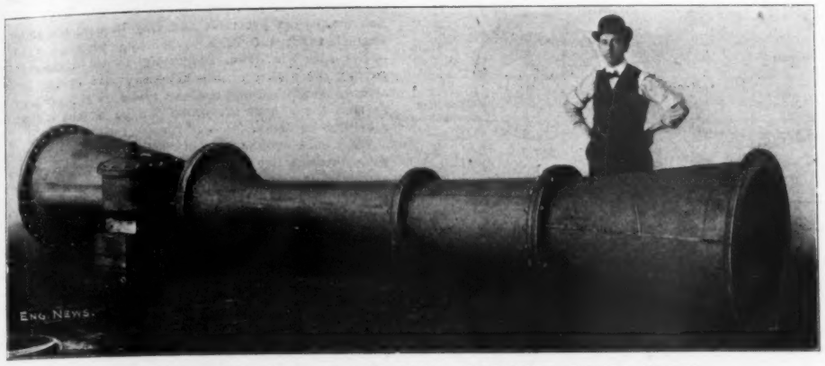


FIG. 1. GENERAL VIEW OF 30-IN. "PREMIER" WATER METER.
Arthur S. Tuttle, M. Am. Soc. C. E., New York City, Inventor. National Meter Co., New York City. Manufacturers.

branch streams on the coast, as used by the U. S. Coast Survey, but the writer considers it dangerous to use where anything like accuracy is required.

THE PREMIER PROPORTIONAL DISPLACEMENT WATER METER.

The accompanying engravings illustrate a new form of water meter of the proportional displacement type which has been worked out after about four years of experimental investigation by Mr. Arthur S. Tuttle, M. Am. Soc. C. E., Principal Assistant Engineer, Board of Estimate and Apportionment of New York city. This meter is known as the "Premier" meter and is manufactured by the National Meter Co., of New York city. It consists, first, of a Venturi tube, which may be described as a short contracting section of the main, joined to an expanding section by a short cylindrical section. The diameter of the connecting cylinder is the same as that of the smaller end of each of the two cones, while the larger diameters of the cones correspond with that of the pipe line on which the meter is to be used. These parts are designated respectively as the up-stream cone, down-stream cone, and throat. The tube is built into and forms a part of the main to be measured.

The second part of the apparatus consists of a by-pass leading from the main just above the up-stream end of the up-stream cone, and again meeting it at the throat, the junction being effected by an acute angle and through a contracting cone and throat. The by-pass, with its cone and throat, are of a much smaller diameter than the main and its similar cone and throat, and each part of the by-pass bears a definite and known relation to the similar parts of the main.

The third part of the meter consists of the recorder, which is a specially designed displacement meter, inserted on the by-pass pipe, and so constructed that it registers the entire flow through the main.

As a whole, the meter may be said to consist of a large and a small Venturi tube, merging into one at their throats and having a common down-stream cone, with a recording apparatus placed on the pipe leading to the smaller Venturi but measuring the total flow through both tubes, which is equivalent to that of the main.

From the theory of flow through Venturi tubes, as fully explained in text books on hydraulics and as determined by the experiments of Clemens Herschel, M. Am. Soc. C. E. (Trans. Am. Soc. C. E., Vol. 17, page 228), it appears that the temporary loss of head at the throat of tubes of similar design, but of different sizes, due to the temporary increase in velocity, is the same in each for any given velocity in the main, from which it follows that when the same temporary losses of head exist at the throats of each of two similar tubes of this character, the velocity in each main must be the same, and that the flow through each must be in direct proportion to their respective areas, this being the principle upon which the meter is based.

The positive and certain action of the apparatus becomes clearer when we consider a specific case. Assume that water is flowing through a main with a velocity of 3 ft. per second, corresponding with a velocity head of 0.14 ft. In passing through a meter having a throat area one-ninth that of the main, this velocity becomes 27 ft. per second, with a corresponding velocity head of 11.30 ft., so that the pressure head is reduced 11.16 ft. at the throat. In the Premier meter, this very appreciable drop in pressure takes place at the common throat, and makes itself equally felt in the large and small up-stream cones, producing from the law already explained, a flow in each, the relative volume of which is a constant. The meter is designed to meet given requirements, and so that this positive but temporary loss of head is sufficient to secure the desired effect on the flow through the by-pass; such effect can only be secured by some form of contraction in the main, of which the one proposed offers the best advantages.

To overcome the slight friction of the recording apparatus, special features of a minor character are introduced in the meter, by means of which the velocity of the main is reduced in the by-pass, thus also largely removing danger of the entrance of material floating in the water, which possibility can be made still more remote by placing a screen over the entrance to the by-pass.

The meter will, it is thought, commend itself to water-works officials for use on mains for many reasons, among which may be noted the following: (1) It is simple in construction and can be set up without expert supervision, and the recording apparatus not only can be read by an unskilled attendant but needs no adjustment. (2) It is entirely self-operating, and if not visited regularly, the record is continued for an indefinite time. (3) It may be wholly buried in the ground in like manner to other parts of the pipe line, requiring only a small chamber around the recording apparatus, which latter is in every external respect similar to an ordinary house meter. (4) The constant motion of water through all of its parts reduces danger of freezing to a minimum, the same being no greater than exists at other points on the main which are similarly exposed; this danger is wholly removed if the meter is placed far enough below the surface. (5) No greater friction loss is produced in the main by this meter, than by those of any other type. An automatic recording apparatus is being perfected which will leave a graphic record of the flow through the main at all hours, and in a form which will be appreciated as convenient.

The meter shown by Figs. 1 and 2, is for a 30-in. main, and will form a part of the exhibit of the National Meter Co. at the St. Louis Fair. It is the first one built for actual service, although work is now in progress on two 16-in. meters of the same pattern, with automatic recorders, for the city of Holyoke, Mass. Tests of experimental meters of this type have been in process for about four years. A summary of the results of these tests are given by Tables I and II. These results, it is thought, show that the meter will rank well in accuracy with other existing devices for the commercial measurement of water. For the information from which this description has been prepared we are indebted to the National Meter Co. of New York city.

FIG. 2. SECTIONAL PLAN OF 30-IN "PREMIER" METER.

TABLE I.—GIVING SUMMARY OF RESULTS OF TESTS OF A 12-IN. "PREMIER" METER, BASED ON WEIR MEASUREMENT.

Duration of test in minutes.	Velocity in main ft. per sec.	Meter record expressed in terms of volume determined by tank measurem't. Per cent.
30	0.75	95.2
60	0.80	99.7
20	0.90	96.6
10	1.1	99.2
30	1.6	97.9
20	1.8	100.1
60	2.1	100.3
10	2.3	99.8
30	3.1	100.0
10	3.2	100.0
70	3.3	100.6

Note: The weir used for these experiments was 2 ft. long and had end contractions. The Hamilton Smith formula was used for the calculations. The diameter of the throat of the meter was one-third the diameter of the main.

TABLE II.—GIVING SUMMARY OF RESULTS OF TESTS OF A 12-IN. "PREMIER" METER, BASED ON TANK MEASUREMENT.

Velocity in main ft. per sec.	Cu. ft. measured in tank.	Cu. ft. registered by meter.	Accuracy of meter, per cent.
0.95	204.75	200	97.7
1.04	207.75	200	96.3
1.07	101.00	100	99.0
1.15	202.50	200	98.8
1.21	100.75	100	99.2
1.23	206.75	200	96.7
1.25	309.00	300	97.1
3.30	298.50	300	100.5
3.33	201.00	200	99.5
3.34	200.00	200	100.0
4.90	298.75	300	100.4
4.92	499.74	500	100.1
6.38	201.00	200	99.5
6.43	99.50	100	100.5
6.51	200.00	200	100.0
6.53	300.74	300	99.7
	3,631.73	3,600	99.1

Note: The diameter of the throat of the meter was one-third the diameter of the main. The volume of water admitted to the measuring tank was in each case determined by the reading on the meter dial, the supply being cut off when the registration showed that the desired amount had been delivered.

A NOVEL FORM OR MOLD FOR CONCRETE CATCH-BASINS.*

By H. G. Clark.†

The numerous brick catchbasins built on Keney Park cost about $25 apiece, without the castings. In order to reduce the expense and to make catchbasins which would not be broken up by frost, the writer constructed a form for making the catchbasin of concrete.

The apparatus consists of an outside and an inside cylinder. The outer cylinder is made of 2-in. pine plank, bolted to iron hoops, one at each end and one in the middle. The cylinder is divided into three sections, and is held together when in use by bolts which pass through slotted holes in right-angle bends in the ends of each hoop and also through a vertical iron rod 1 in. × ⅛-in. standing

*A paper read at the 20th annual meeting of the Connecticut Society of Civil Engineers.
†Hartford, Conn.

between each pair of lugs on the hoops. The sections are bolted together and lowered into the hole and are removed in three sections by pulling on the lifting rods which lift the bolts out of the slots in the hoop lugs.

The inside cylinder is made of 2-in. pine staves bolted to 2-in. spruce circular segments, with ⅝-in. spacing between the staves to allow for swelling. The outside is covered with No. 16 galvanized iron, which presents a smooth and waterproof surface to the concrete. This cylinder is divided into three sections joined by strap hinges at two of the joints, while at the third joint is a wedge-shaped stave. To remove the cylinder the wedge is first drawn out, then the cylinder closes on its hinges and frees itself from the concrete. Round wooden plugs are placed between the cylinders at the required level for pipe inlets or outlets.

To reduce the diameter of the top of the catchbasins a cone-shaped form is placed after the lower part is finished, and the concrete is filled in till the diameter corresponds to the casting to be used.

The outside cone is made in one piece, as shown in the cut. The inside cone is made of sectional staves bolted to iron cleats and covered on the outside with galvanized iron, the alternate staves overlapping.

Twenty-six catchbasins have been built with these forms in Keney Park, at a cost of about $7 apiece for the concrete in place, or about $10 apiece including digging the hole, etc.

Brick catchbasins of the same size built by day labor cost $20 to $25 apiece without the castings.

LOCOMOTIVE-TESTING PLANT AT THE ST. LOUIS EXPOSITION.

In our issue of Nov. 26, 1903, we published an account of the locomotive-testing plant which is to be operated at the St. Louis Exposition, under the direction of the Pennsylvania R. R. Co., with the aid of an Advisory Committee representing the American Society of Mechanical Engineers and the American Railway Master Mechanics' Association. The plant will form a part of the Pennsylvania Railroad exhibit in the Transportation Building at St. Louis. From a bulletin just issued by the company we reprint the following description of the plant, and reproduce cuts showing the general arrangement. An additional drawing shows in detail the Alden absorption dynamometer, which forms an essential part of the plant.

The locomotive under test is carried on supporting wheels whose axles are extended to receive absorption brakes. The turning of the driving wheels causes the supporting wheels to revolve, but these are retarded by the brakes to any extent desired.

The work actually done by the locomotive consists in overcoming the frictional resistance of the supporting wheels and brakes, the resulting force exerted at the drawbar being measured by a traction dynamometer.

The upper faces of the supporting wheels "J" are at the level of the tracks and of the floor of the building, with a pit of sufficient depth for these wheels and their supports.

The base of the plant consists of two longitudinal bed plates, "A," of cast iron, secured to concrete foundations of ample depth for the weight to be carried, and to resist the shocks transmitted from the locomotive driving wheels when revolving at high velocities. The bed plates are provided with T slots running longitudinally, and by means of suitable bolts the pedestals "B" are secured to them, thus permitting adjustment lengthwise, in order that the supporting wheels may be located to correspond with the spacing of the driving wheels of the locomotive to be tested.

There will be two sets of supporting wheels, one consisting of three pairs, 72 ins. in diameter, for use under passenger types of locomotives having large driving wheels and one set of five pairs, 50 ins. in diameter, to be used under locomotives with smaller wheels and designed for freight service. The pedestals will be of two heights; the lower ones for the supporting wheels of larger diameter, the higher ones for the smaller supporting wheels.

The journal boxes carried in the pedestals are self-adjusting so as to secure uniform support for the journals. The lower half of the box contains a bronze bearing of suitable composition, while the upper half, which acts only as a cap and carries no weight, is made of cast iron. The bearing surface is ample for the weight to be carried, but in order to provide against any possibility of heating, the journal boxes are cored out and arranged for cooling by water circulation. The lubrication is accomplished by two chains over each journal dipping into a bath of oil.

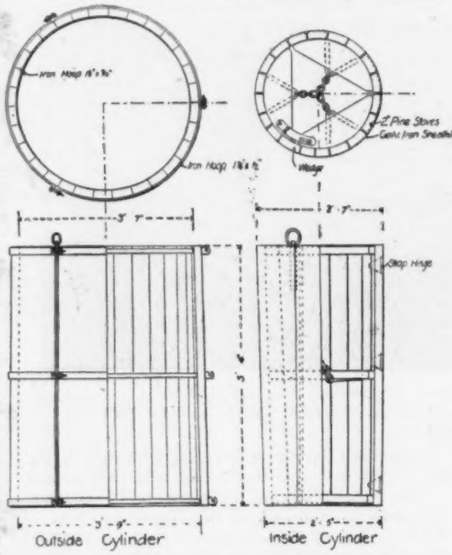


Fig. 1. Form for Concrete Catch Basins.

On the ends of each supporting shaft are the absorption brakes "C," which form the resistance which the locomotive must overcome, in order to exert its tractive effort at the drawbar. They are designed on a plan which enables them to work with perfect smoothness, to be used with ease and convenience and to have a large capacity. This type of brake was first used as a dynamometer at the Worcester Polytechnic Institute, and is the invention of Mr. G. I. Alden, M. M. E., formerly a member of the Institute faculty.

This brake in its simplest form consists of:

1. A smooth, circular, revolvable cast-iron disk, with radial grooves, keyed to the shaft which transmits the power to be absorbed.
2. A non-revolvable housing having its bearings upon the hub of the revolvable disk.
3. A pair of thin copper plates fastened to the housing, one face of each copper plate being close and parallel to the sides of the revolvable disk, the other face of each plate having back of it a chamber in the housing.
4. A system of piping and connections by means of which water under pressure can be circulated through the chambers between the copper plates and the housing.
5. A system of piping and connections by means of which oil is circulated in such manner as to insure perfect lubrication of the copper plates which are next to the revolvable cast-iron disk.

To insure sufficient capacity, each brake is provided with two disks revolving inside of each housing with a suitable arrangement of copper plates and water chambers, to allow pressure to be exerted on both sides of each disk.

Oil for lubrication between the revolving surfaces enters near the hub of the disks and is carried by centrifugal force along the radial grooves in their sides and out to their peripheries, completing the circuit through external tubes.

The housings of the brakes are secured against turning by rods attached to brackets "K," which in turn are held to the sides of the bed plates by bolts in T slots.

The seats on the supporting shafts for the hubs of the brake disks are tapered, as shown at "D," keys being placed in the shaft and hub to prevent turning. Nuts on the smaller end hold the hubs in position. Both absorption brakes are provided, and may be used either on the shafts having the 72-in. supporting wheels, or on the shafts with the 50-in. supporting wheels, means for removing the brakes readily being provided by the taper fit already mentioned and a nut at the large end of the taper, so that the hub of the brake can be backed off without difficulty or delay.

When the brakes are in use, water under pressure flows through the chambers in the housings, pressing the copper plates against the sides of the revolving disks and causing resistance to their rotation. The pressure of the water is regulated by valves controlling both the inlet and outlet independently. The water thus performs the double function of supplying by its pressure, the required friction, and by its rate of flow means of carrying off the heat generated.

The pipes leading to and discharging from the brakes are brought together at one point where all the valves will be located, so that the pressure and rate of flow can be readily adjusted to the work being done.

To keep the speed of the locomotive constant, would ordinarily require hand manipulation of the valves controlling the ingoing and outflowing water, but in order to secure as nearly as possible constant speed, there is a by-pass around the main valve controlling the supply of water for all the brakes, and in this by-pass is an automatic valve controlled by the speed of the locomotive. If the speed increases beyond the desired number of revolutions per minute, the by-pass valve opens, so as to increase the pressure on the brakes, and if on the other hand, the speed of the locomotive falls below that desired, the automatic valve closes, and decreases the pressure on the brakes.

The supporting wheels resemble in form, the usual locomotive driving wheels, having cast steel centers with tires shrunk on, and held in addition by retaining rings.

The contour of the tire is approximately that of the head of a rail, but provided with means of keeping away from its bearing surface the oil which will necessarily drip from the locomotive while running.

The pit containing the parts already mentioned, is extended sufficiently to provide room for the storage of the supporting wheels, axles, brakes and pedestals which are not in use, and provides storage for such other supplies and appliances as will be necessary for the operation of the plant. The floor covering this portion of the pit, is made in sections, so that it can be removed as occasion may require. The central portion of the pit, however, will be entirely open with the exception of sufficient platform to enable those taking part in the tests to secure indicator cards, make observations of temperatures and obtain other information of this character.

A traveling electric crane "E" of 10 tons capacity, and having a span of 43 ft. between centers of runways "F," serves the entire space occupied by the testing plant, also sufficient space beyond the pilot of the longest locomotive to be tested, to reach the cars loaded with supplies for the plant. The crane will be used for handling the supporting wheels, axles, brakes, pedestals and other parts, when necessary to change their setting and further, for handling all of the coal used during the tests.

The water required for locomotives under test, will be weighed in two tanks, filled alternately, and run from these into a third tank, from which it will be taken by piping to the connections for the injectors. As a check on the weights thus obtained, the whole supply used will

Fig. 2. View of Catch Basin Form in Sections.

Fig. 3. View of Catch Basin Form Assembled.

be metered and readings taken at such intervals as will enable the amount shown by weighing to be compared.

The traction dynamometer "G" which measures the drawbar pull of the locomotive, is of the lever type and is constructed on the "Emery" principle, in which flexible steel plates take the place of knife edges used in ordinary scales. The weight of each lever is taken by a vertical plate in a plane intersecting that of the receiving fulcrum plates at their center of rotation, thus relieving these plates of all transverse load. The yoke embracing the dynamometer and to which the drawbar is attached, is also mounted on flexible plates and braced by long and flexible rods, to insure frictionless motion in the horizontal plane only.

The total motion of this yoke and drawbar, due to the leverage of the machine and to stress of parts when under full load, does not exceed four one-hundredths of an inch, so that a locomotive exerting a drawbar pull equal to the full capacity of the dynamometer, will not move forward on the supporting wheels more than the amount specified. The drawbar is provided with a ball joint, to allow for any side motion of the locomotive, or motion of the locomotive on its springs.

Near the base of the dynamometer, the oscillating motion of the ends of the last levers, is transformed into a rotary motion by means of steel belts wrapped around a drum and kept in constant tension by suitable clamping devices. The belt drum is mounted on a tube guided in ball bearings, and inside of it is a rod, the upper part of which is securely fastened to the tube, the lower end being firmly attached to the frame of the machine. It will thus be seen that when the belt drum is rotated, the rod inside of the tube is in torsion, and this resistance forms part of the total resistance of the machine, and is a constant for the same travel of the recording pen.

To the upper end of the tube already mentioned, are secured two radial arms, the extreme ends of which are finished to a circle having its center at the center of the tube. The angular motion at the end of one arm imparts straight line motion to a carriage, guided by a grooved track and carrying the recording pen. The opposite arm is coupled by steel belts to a rotary oil dash pot, to reduce violent oscillations of the recording pen, the extent of which can be controlled as desired. The principal resistances in the dynamometer are flat springs, placed under the second levers and deflected by the motion of these levers. There are three sets of these springs, varying in resistance so that a travel of 8 ins. of the recording pen corresponds to a drawbar pull of either 80,000 lbs., 40,000 lbs. or 16,000 lbs., as may be desired. The drawbar pull is traced upon a strip of paper 18 ins. wide, made to travel at a known rate for each mile run by the locomotive, and this will form the permanent record of the drawbar pull in each test.

The yoke and drawbar of the dynamometer can be adjusted vertically through a range of 12 ins. by means of a wheel "H," in order that the different heights of locomotive drawbars can be accommodated.

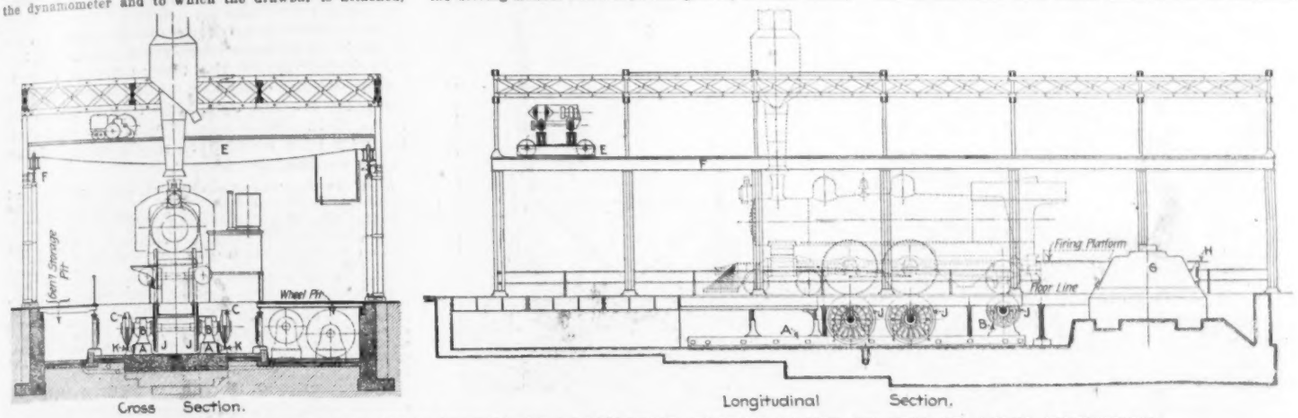
The smoke from the locomotive will be carried out of the building by a stack, which can be moved longitudinally of the plant to any position required, and the lower portion of which will be made telescopic, so that it can be raised and lowered for adjustment, and permit the passage of the electric crane, when necessary. The stack has deflectors, so that the sparks discharged by the locomotive can be caught, weighed and form a part of the data obtained.

The instruments necessary to get full information for the tests will consist, in addition to the dynamometer, of steam engine indicators, gages for steam pressures, draft gages for smoke box, fire box and ash pan, thermometers for temperatures in the smoke box, calorimeters for getting the quality of the steam, a revolution counter and a tachometer for showing the speed in revolutions per minute.

Means for bringing the locomotive safely to its position on the plant form a most important part of the installation. The supporting wheels having been placed in position corresponding to the spacing of the drivers, I-beams resting on the supporting shafts, and extending the full length of the pit, will be bolted securely to the inside faces of the supporting wheels. Supports at the ends of the pit and at as many intermediate points as may be necessary will be provided. On the upper flange of the I-beams is riveted a grooved rail, so located that the flanges of the driving wheels will run in this groove; in other words, the locomotive will be moved to its position on the plant by being run on the flanges of its driving wheels, leaving the treads free to come into position upon the supporting wheels. When in place, the special rails and I-beams will be disconnected from the supporting wheels and removed, so as not to interfere with the operation of the plant. Provision will also be made for taking care of the driving wheels without flanges, which will be run over the same grooved rails, the grooves being filled by a suitable section of rolled steel.

A director of tests will be in direct charge of the plant, and of all tests made. Under him will be an assistant and a foreman, who will give his attention to the machinery, care of the instruments and other necessary work of this character. There will be a large staff of observers for the coal and water used, for taking indicator cards, temperatures, and readings from all the instruments forming the equipment of the plant.

In order that all of the data obtained may be worked up promptly, computers will be employed, so that the data coming from the observers on suitable blanks will be tabulated and final results for comparison completed for each test, before similar data for the next run comes to the computing room. A force of 25 men will be constantly employed. All apparatus has been carefully selected and the most approved methods will be used to insure accuracy; the results will be put in a form convenient for reference.

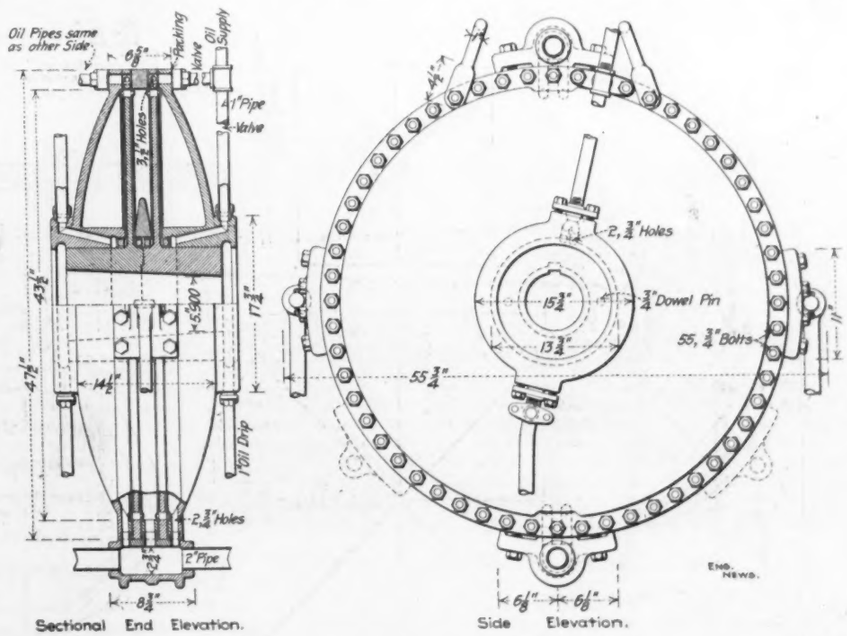


GENERAL ELEVATION AND CROSS-SECTION OF LOCOMOTIVE TESTING PLANT AT THE ST. LOUIS EXPOSITION.
Erected and Operated by the Pennsylvania Railroad System.

A WATER TANK-TOWER AND ITS COLLAPSE.

The photograph reproduced in Fig. 1, herewith, shows the ruins of a water tank-tower at Abilene, Tex., which collapsed immediately after construction. The tower was designed for the State of Texas by an architect employed to plan a water-supply system in which the tower was included. The contract for building and erecting the structure was let to the Means & Fulton Iron Works of Birmingham, Ala. Through the courtesy of Mr. A. V. Brown, engineer of the contractor, we are enabled to show drawings of the structure and state the circumstances under which the work was done.

The bids for the construction of this tower were



ELEVATION AND SECTION OF ABSORPTION DYNAMOMETER FOR LOCOMOTIVE TESTING PLANT.
Designed and Built by Geo. I. Alden, M. Am. Soc. M. E.

asked on a general design drawing prepared by the architect and a sheet of "specifications" accompanying and supplementing the drawing. The contract was executed on the same basis, and except for one or two minor variations the structure as built was in accordance with the drawing and specification. This drawing is reproduced, in sub-

stantial identity, in Fig. 2 herewith. The "specifications," which are brief enough to bear reprinting in full, were as follows:

TOWER.—Build tower as shown in detail drawings, sizes and weight steel as shown and marked on plans, all to be thoroughly riveted together with standard riveting and connections and as shown in details.

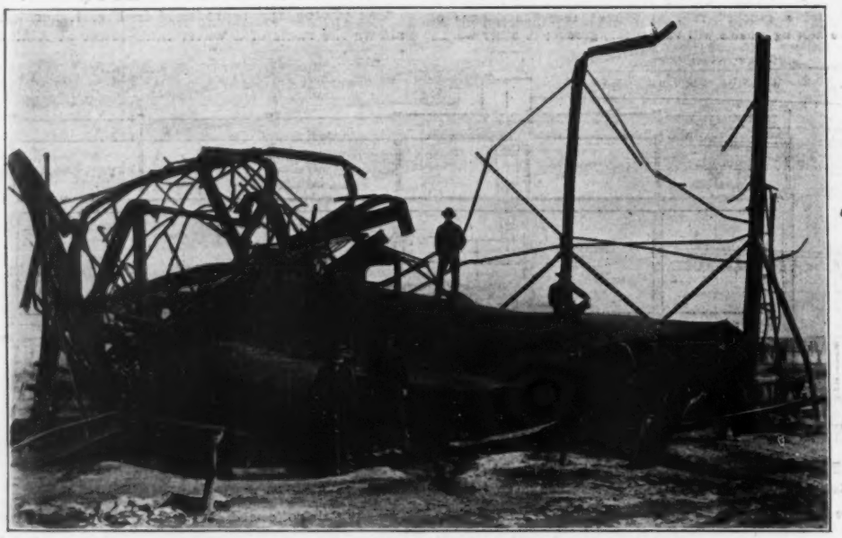


FIG. 1. VIEW OF WRECKED WATER TANK-TOWER AT ABILENE, TEXAS.

PLATES.—Of strictly first-class grey cast iron absolutely free from defects of any kind and turned off true on bearings.

COLUMNS.—Of I-beams, size and weight as shown, perfectly straight and planed off for accurate bearings. These columns may be of latticed channels, if preferred, but details must be approved by architect before change will be allowed.

PLATFORM.—To be ½ × 2-in. flat iron strips, spaced not over 2 ins. apart and riveted to bearings.

LADDERS.—Build ladder from ground to platform and from platform to top of tank as shown in drawings, braced back to tower construction every six feet with light angles.

RAILING.—Railing around platform to be gas pipes, as shown, well secured.

SHOP DRAWINGS.—Must be furnished to the architect, in duplicate for approval before work is started.

As stated, bids were asked, and a contract signed, on the basis of the plan and specification. The contractor says:

In bidding on this work we objected to the design and wired that we would only bid at the State's risk, and were ordered by the architect to carry out the plans as he had given them. This was done with all the accuracy possible.

While the specification speaks of the "size and weight as shown" in regard to the columns, it will be seen that the drawing merely says "12-in. I," and gives no weight. The contractor used a 12-in. 31½-lb. I-beam. The detailing where indicated on the architect's drawing, was done as nearly as possible to the drawing. Thus, the splices of the columns, shown as being made with two 10 × ⅝ × 48-in. plates with either five or six rivets on each side of the joint, were detailed with the indicated size of splice-plates, but seven rivets were used on each side, evidently with the intention of not exceeding a 6-in. spacing. Again, in the diagonal side-bracing, where the drawing shows the two single-angle diagonals with the outstanding leg turned the same way and without a splice-plate at the crossing, the contractor blocked out the flange of one angle to allow the other diagonal to pass, and pinned the diagonals together with one rivet. Some details of the structure, taken from the contractor's working drawings, are shown in Fig. 3.

As already stated, this tower collapsed after it was practically completed, while being filled with water for the first time. The tank had held between 10 ft. and 11 ft. of water the week before, but had been emptied to recalk several leaks. In the words of Mr. Brown:

When the structure was completed, except painting and riveting of a balcony floor, water was pumped into the tank. From the time spent in pumping there was supposed to have been from 16 to 17 ft. of water in the tank, when the entire structure collapsed, falling within its own foundation and making a complete wreck (see the view Fig. 1.—Ed.). The examination of the wreckage pointed to the weakness of the framework, as the tank came down in one piece, with the bottom split full length, caused, the writer believes, from its contact with the earth, as it appears to have struck on its side. No one witnessed the fall its entire length. Two young men were standing near the tower when they heard a crack, as they explained like the report of a rifle, and they turned and fled.

Subsequently, at the request of the contractor, several engineering firms examined the design of the tower for criticism. One of these firms, Wilson & Alber, of Birmingham, Ala., reports weaknesses in the design as follows:

1. The bottom plates of the tank are very much overstrained, in fact so much so that their rupture at the first filling of the tank could have been expected. A strip of 1 ft. in width bears the load of 1,265 lbs. per lin. ft., including the weight of bottom plate. The bearing channels being 4.5 ft. apart, this strip should be strong enough to resist a bending moment at the supporting channels of 25,616 in.-lbs., causing in the 12 × ⅜-in. strip a fiber stress of 91,100 lbs. per sq. in., and half this amount at centers between bearing channels, or 45,550 lbs. Considering that by riveting the plates are weakened approximately 30% at the seams, and the stresses proportionately increased, the bottom plates are at numerous points strained by the filling of the tank beyond their ultimate tensile strength.

2. On reasonable assumptions as to the division of load

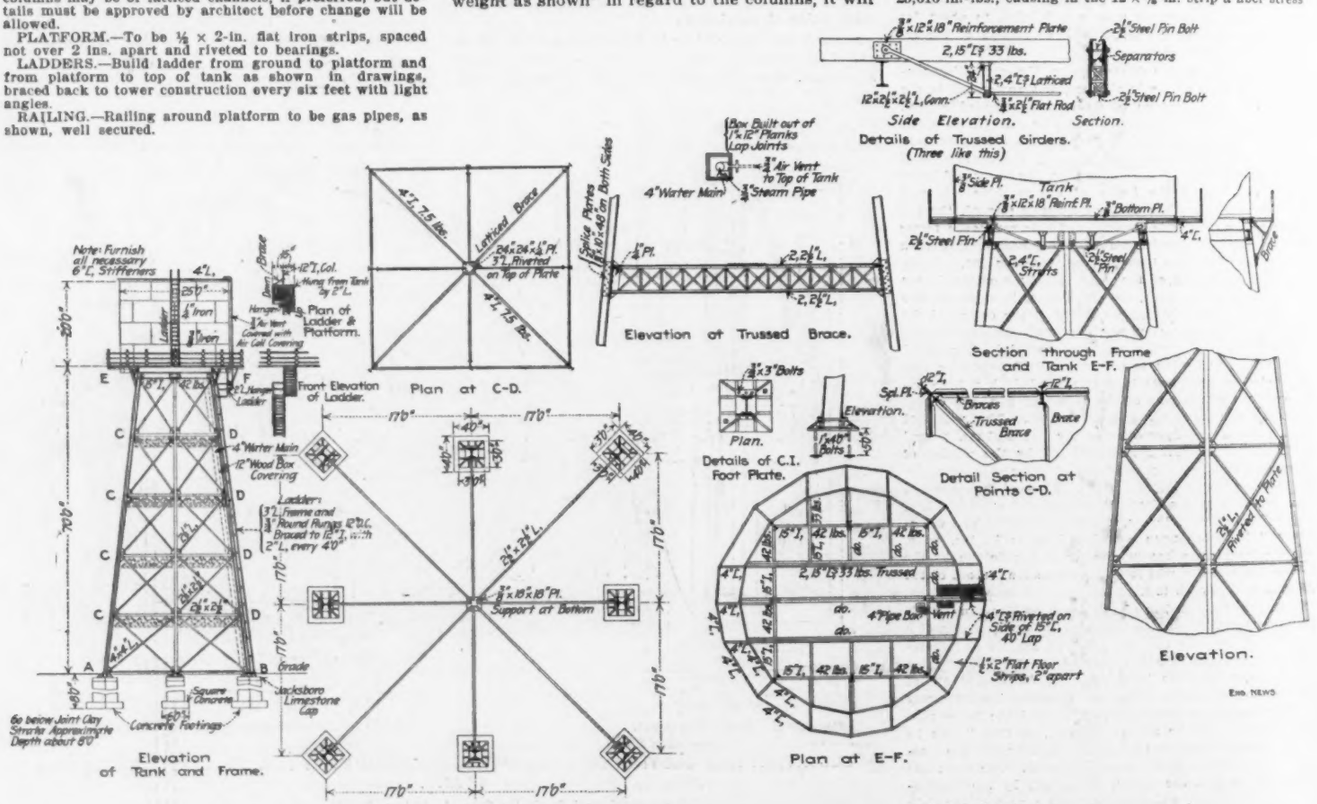


FIG. 2. ARCHITECT'S CONTRACT DRAWING OF ABILENE TANK-TOWER.

TANK.—To be 25 ft. in diameter and 20 ft. high, of steel plates as shown in drawings, bottom ⅝, two first sections ⅝, and other sections ¼-in., all standard riveted and made absolutely water tight. Stiffen with 4-in. angles around top and 6-in. channel* on inside, about six feet apart. Bottom of tank to have flanged openings for reception of 6-in. riser pipe.

*In place of these channels the contractors used 4 × 4 × ⅝-in. angles, set vertically.

on the tank floor framing, the main beam A B (see sketch Fig. 4) must be considered much overstrained, as its extreme fiber stress of 27,040 lbs. reaches nearly the elastic limit of average steel of such size.

3. The columns are very unequally loaded. Column B (Fig. 4) receives 10,000 lbs. more than twice the amount which the corner column A receives. In its lowest section, column B carries a load from weight of structure and water alone, without wind, of about 138,000 lbs., which on a 12-in. 40-lb. I-beam gives a stress of 11,600 lbs. per sq. in. If this column be supposed to fail in the direction of its flanges, with a length equal to 13.6 ft., the factor of safety by Gordon's formula is only 1.7 to 2.5, depending upon the formula used. Further, since the cross-bracing is very insufficient, the column may be considered almost unsupported on its whole length in the direction of the web; calculation for crippling in this direction gives a result even slightly worse than the above.

This examination was directed only to the general design, and did not consider the details. Many of the details are equally faulty, doubtless because of close adherence to the indications of the general drawing, carrying out the architect's specific instruction. However, the weakness of the main members, especially of the floor, as pointed out by the examining engineers, is sufficient to account for the collapse. More detailed criticism by our readers will be welcome.

An interesting feature of the whole case is that the contractor, after objecting to the design as dangerous, offered "to build the same capacity tank, same elevation, for $2,000 less than the architect's plan, guaranteeing the structure to be efficient."

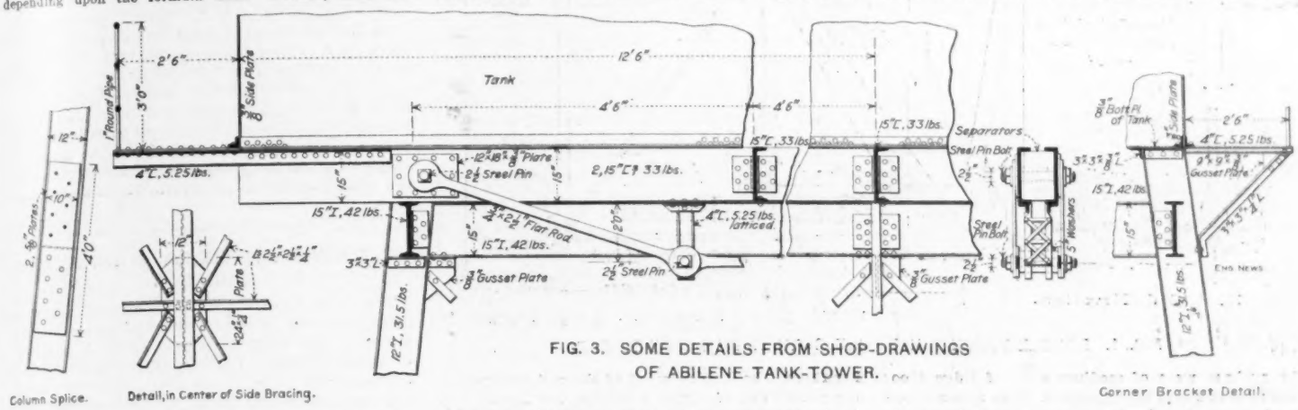


FIG. 3. SOME DETAILS FROM SHOP-DRAWINGS OF ABILENE TANK-TOWER.

SEWER CONTRACTOR'S RECORDS.

By Ernest McCullough, C. E.*

When a contractor takes a contract to put in sewers, he expects to connect many of the houses along the line of the sewers and must often cut off old private sewers and make new connections. It is therefore necessary to organize a house-drain department with a man especially detailed to attend to this work.

The company employing the writer uses machinery to excavate and backfill, and the progress of each machine is from 200 to 700 or 800 ft. per day. In our St. Louis contract three machines were at work with the result that a fifteen months' contract was practically completed after only ten months' work. The labor of looking after many hundreds of house connections could not be carelessly left to any one who could send a water boy to the City Hall for permits. The method there adopted, however, for taking care of this detail did not provide for rapid and systematic work, and the writer developed the system here described.

Generally, it must be ascertained whether the house plumbing is in proper condition before a sewer connection can be made. As the necessity for requesting an inspection by the city officials leads to delays and many deals must be held up for quite a time, the loose-leaf system was adopted as the best for the work. Upon the assumption that an endeavor should be made to obtain all the connection work possible, complete plats are secured which have on them every subdivision and the names of all owners of record. After the plumbing inspectors report on the condition of the plumbing, a systematic house-to-house canvas is then made with blank contracts.

The blank used may be described as follows: The sheet is the size of an ordinary sheet of letter paper, 8½ × 11 ins., and is made of a medium heavy, tough linen paper. It has two perforations near the top so that it may be inserted in adjustable covers. The first four lines are filled in from the plats and the sheets filed in the cover, consecutively with a number in red ink at the two lower corners. The same number is placed in red ink in the lot on the plat to which this sheet refers. The plats then become the index for the system.

A plumbing inspection is next asked for and noted on the sheet. The date of the report is marked when received. The property owners are notified of what is wrong, and when the work is done another inspection is asked for and the O. K. report is noted. The contracts are now sent to the property owners properly filled in with amount for which the work will be done, but not dated or signed. If the property owner signs and returns the contract then they are dated and signed by the contractor and the owner is given a copy. The remainder of the lines from the fifth to the eighth inclusive are filled on the record sheet. When the permit is obtained the date and number are filled in and the record sheet is removed to the second cover and filed by its consecutive number as shown at the bottom.

The foreman of the house-drain gang reports when the work is completed and the proper note is made and the bill sent out. All additional information is placed in the spaces for "Remarks," and the sheet is left in this cover until the bill is paid, when it is removed to a permanent file.

Three covers are used; the first book shows all prospective business; the second shows unfinished business, and the third is used when the transaction is closed. If some individual drainlayer or plumber obtains a contract, the number and date of the permit from the city records is properly entered, and in the remarks is placed his name and address. Then that sheet is removed to the permanent file in its proper place. If complaints afterwards come in as to the sinking of trenches, it is easy this way to ascertain who is responsible.

As the sheets are the size of an ordinary letter-head, all correspondence relating to any particular job is numbered to correspond with the sheet it relates to and is filed with the sheet. If postal cards or note sheets are used these are pasted on sheets of the proper size. If complaints or additional letters are received after a sheet is permanently filed, these are placed in the book containing unfinished business until they are attended to and they are then also placed in the permanent file.

An attempt is made to treat everyone alike, and the estimate is made about as follows, it being understood that the figures given are simply illustrative: For entering sewer, $5.00. For each lineal foot under car-tracks or other obstructions requiring tunnelling, $1.00. For each lineal foot in a macadamized or paved street, 85 cts. For each lineal foot inside the property line, 75 cts. For each trap furnished and set, $5.00. The foreman reports on each job the number of pieces of pipe used and the time consumed in laying, so that the actual cost can be readily obtained.

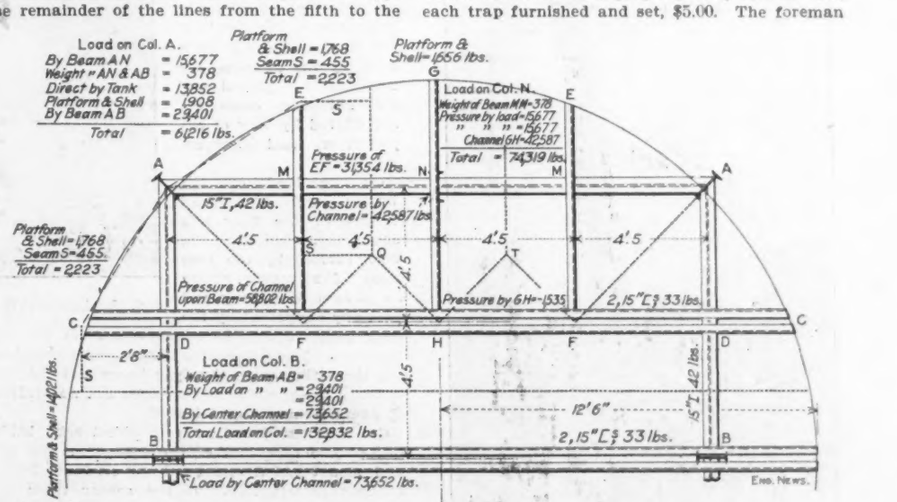

Load on Col. A.
By Beam AN = 15677
Weight "AN & AB = 378
Direct by Tank = 13852
Platform & Shell = 1908
By Beam AB = 23401
Total = 61216 lbs.
Platform & Shell = 1768
Seam S = 455
Total = 2223
Platform & Shell = 1656 lbs.
Load on Col. N.
Weight of Beam MN = 378
Pressure by load = 15677
Channel GH = 42587
Total = 74319 lbs.
Pressure of EF = 31354 lbs.
15"I, 42 lbs.
Pressure by Channel = 42587 lbs.
4'.5
Pressure of Channel upon Beam = 58902 lbs.
Pressure by GH = 1535
2, 15"C 33 lbs.
Load on Col. B.
Weight of Beam AB = 378
By Load on " " = 23401
" " " = 23401
By Center Channel = 73652
Total Load on Col. = 132832 lbs.
12'6"
Load by Center Channel = 73652 lbs.
Eng. News.

FIG. 4. DIAGRAM OF TANK-FLOOR FRAMING AND COLUMNS.
[Dotted lines indicate approximate distribution of tank load on floor beams.]

HOUSE DRAIN RECORDS.

Street and number .....
Owner of record .....
Address .....
Description of property .....
Plumbing inspection asked ..... Reported .....
Defects in plumbing .....
..... Reported O. K. .....
Contracts mailed ..... Signed by us .....
Amount of contract ..... Estimate of material and work to be done .....
Date of permit ..... No. of permit .....
Work done ..... Billed .....

Remarks.

.....
Date paid .....

*Engineer, Municipal Engineering and Contracting Co., Chicago, Ill.

A PIN BRIDGE THAT STOOD WITHOUT AN END POST.

By John C. Moses,* Assoc. M. Am. Soc. C. E.

The bridge referred to is a pin-connected double-track railroad bridge of 78-ft. span, having one center and two outside trusses. It was built in 1887 and the material used was iron, except that this post, taken after its removal from the bridge. The hip-vertical eyebars were struck near their lower end and snapped off squarely through the eyes, leaving the floor beam unsupported. One truck was forcibly wedged into the angle between the main diagonal and bottom chord bars, bending them similarly to the verticals, but not breaking them. The displacement of the end post pulled the portal out of shape, breaking the angles and lattice. The end bottom strut was broken in two. The first two panels of bottom chord eyebars were badly bent.

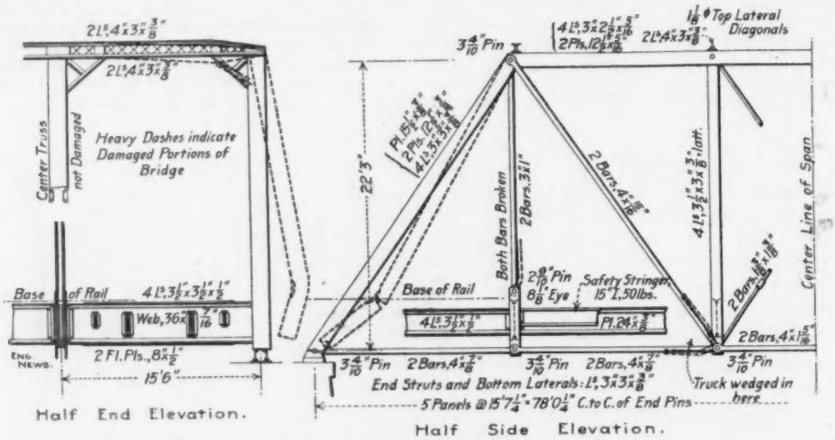


FIG. 1. DOUBLE-TRACK PIN BRIDGE STRUCK BY DERAILED CAR.

The eyebars were of medium steel of Edge Moor specifications and manufacture. The accompanying drawing, Fig. 1, gives the dimensions and data of one of the outside trusses and of the floor system.

The bridge was recently damaged by a derailed freight car, the injuries being confined to one

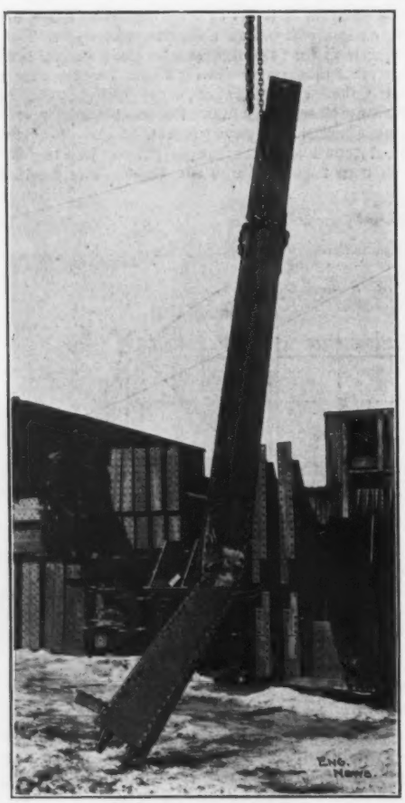


Fig. 2. View of Broken End-Post After Removal from Bridge.

end of one of the outside trusses and as indicated by dotted lines in Fig. 1. The end post was shoved out about 3 ft. and at the same time so crippled that the lower end with its pedestal was lifted free from the abutment. Fig. 2 is a photograph of

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The derailed car was the last but one in the train, being followed only by the caboose, and the load coming on the broken truss was therefore small. The top chord remained in line and level and the unsupported floor beam at the broken vertical dropped down less than one-half inch.

The bridge was examined by the writer shortly after the accident, the bridge having been built by the company by whom he is employed, and the following comments are offered by way of explanation and suggestion.

(1) The load on the bridge and the dead weight of the floor and damaged truss must have been carried by the four lines of stringers acting as girders 78 ft. long and partially supported by the floor beams acting as cantilevers from the center truss. The connection angles and rivets joining the stringers to the floor beam and the floor beam to the posts were examined but no evidence of overstraining was detected.

(2) A center truss on a double-track bridge proved the salvation of the bridge in this case and also enabled one track to continue in use without interruption. If the center truss had been similarly damaged, the floor would no doubt have supported it in a similar way. A bridge of two trusses would have collapsed.

(3) The fracture of the hip-vertical eyebars shows a great contrast in the behavior of the metal at the eyes and in the main bar. The eyebar heads are well formed with an excess area of 75% and seem to have been made by upsetting as at present. The bars were bent edgewise very sharply, but show no cracks at these bends. On the other hand the fractures of the eyes are crystalline and without any signs of reduction of area before breaking. The paint on both sides of the break is undisturbed. The lower half of each eye is in a single piece and the pin hole is not appreciably stretched. Fig. 3 is a photograph of the lower ends of the broken bars taken after removal from the bridge. A chemical analysis of the steel made from a sample cut from the point of fracture gave .04% of sulphur and 0.10% of phosphorus and indicates a probable cause for this sharp break. The material is probably Bessemer steel.

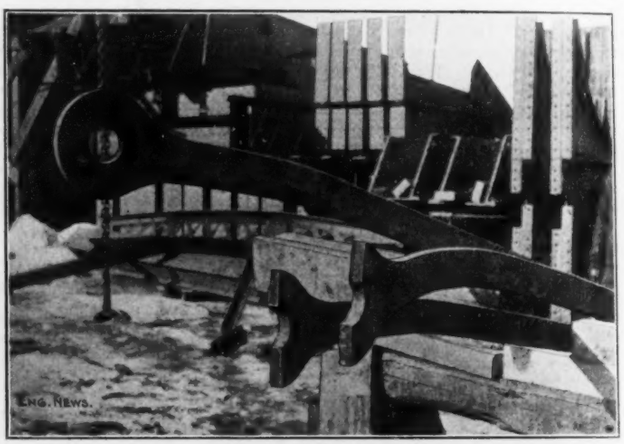

FIG. 3. DAMAGED EYE-BARS AFTER REMOVAL FROM BRIDGE.

(4) A well-riveted floor system having deep stringers riveted between the floor-beam webs adds greatly to the strength and safety of a bridge. Counter and hip-vertical and bottom chord stresses are all probably diminished and the effects of impacts distributed. End floor-beams strongly attached to the end posts and pedestals would still further add to this strength.

(5) It is of course obvious that a modern design for a span of this length would be a plate girder bridge, and riveted trusses are now generally used for spans from 100 to 150 ft. in length. But many short pin bridges are still in use and it is a satisfaction to know that they can sometimes stand severe punishment. We have here one more example of a pin bridge that successfully withstood the total destruction of several of its main members.

THE BUILDING CONSTRUCTION OF THE ST. LOUIS EXHIBITION.

The main buildings of the Louisiana Purchase Exhibition are of great size and attractive appearance, and their structural design is a matter of some interest. While they are built entirely of wood, and therefore do not possess such striking features as the great steel framed buildings of the Columbian Exhibition in Chicago in 1893 with their trusses and arch ribs, etc., yet the structural designs are worthy of some attention. It may be noted here, however, that the U. S. Government Building has steel hinged-arch trusses of 172 ft. span (which we shall illustrate later), and the Steam, Gas and Fuel Building is of steel mill-frame construction, with reinforced concrete walls and roof on the Roebling system. The Fine Arts Building consists of a group of four buildings: a central permanent main building of fireproof construction, two temporary semi-fireproof buildings forming detached wings, and an auxiliary sculpture hall of similar construction to the wings. In Table 1 is given a list of the main buildings, their architects and builders, and their cost, both the contract price and the cost per sq. foot.

STEEL AND TIMBER CONSTRUCTION.

The only important and handsome steel structural work is in the United States Government Building, and consists of three-hinged trussed arches with bottom tie, the span being 172 ft. These were designed by Mr. A. M. Averill, Structural Engineer in the office of the Supervising Architect, U. S. Treasury Department. About the only other steel work is in the steel frame and roof trusses of the Steam, Fuel and Gas Building (or boiler house), which was designed and built by the American Bridge Co.

As to the cost of the buildings with steel or

wooden construction, Mr. P. J. Markmann, the Chief Building Engineer, states that comparing the cost of the steel-frame Government Building with the cost of a few of the wooden-frame buildings of the exhibition company, it would appear that for areas and volumes compared, structural steel construction would have increased the total cost of these buildings by 60 to 120%. This is assuming that the spans in the case of steel construction would be increased by about the same percentage (60 to 120%) over the spans of wooden construction. In other words, he believes that the cost of the principal exhibition structures with main post and truss framing executed in steel, and with increased spans suitable and practicable for that material, would have been increased about 90% on an average. Of course, this additional cost would have made these buildings rather more convenient and desirable for their purpose.

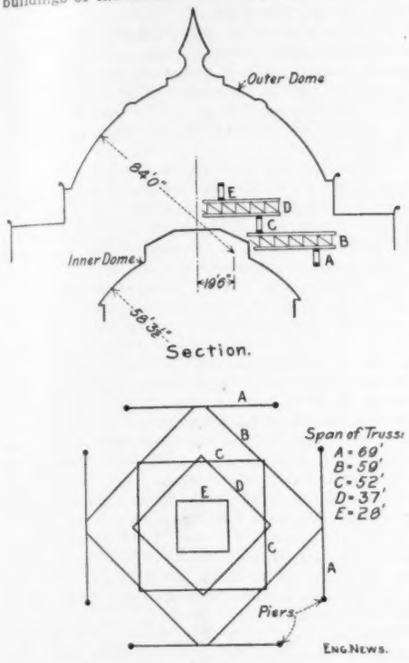

Fig. 1. Diagram of Truss Framing for Dome of Festival Hall; St. Louis Exhibition.

While the smaller cost of these buildings constructed in wood was a potent reason in favor of it, it was not the principal reason. When the exhibition company was getting ready to consider the structural design of the buildings, in the early part of 1902, the professed intention was to have the exhibition take place in 1903. In view of that time limit, and the condition of the steel market at that time, there was practically no choice in the matter. The Supervising Architect of the U. S. Treasury some time later commenced to design a steel frame for his building, before the exhibition was postponed until 1904. The exhibition management, however, never considered a change in construction materials before or after the postponement was decided upon, after its initial decision in favor of timber construction.

All the structural work of the immense buildings at St. Louis was designed under the direction of Mr. P. J. Markmann, Chief Building Engineer, to whom we are indebted for much information concerning the engineering features of this work. One particular point to be noted in connection with this work is that all the drawings had to be made so complete that they could be directly used as working drawings. All the trusses were framed and built on the ground, and the drawings had to give to the carpenter all that information which in the case of steel framing is given by special shop drawings, generally prepared by the contractor at his expense from the general design furnished. These shop drawings, prepared by the contractor, are generally subject to the inspection and approval of the designing bureau. In case of timber framing, no similar custom exists and the contracting parties would hardly be prepared to do it. So the truss and post drawings represented the design as well as the detail. About 200 such drawings had to be prepared for as many different types of trusses in the principal exhibition buildings, while the actual number of trusses built from these drawings is over 3,000. The construction of the buildings was under the charge of Mr. Isaac S. Taylor, Director of Works; the supervision of the architectural work was in charge of Mr. E. L. Masqueray, Chief of Design, who also prepared the architectural designs for several of the minor buildings.

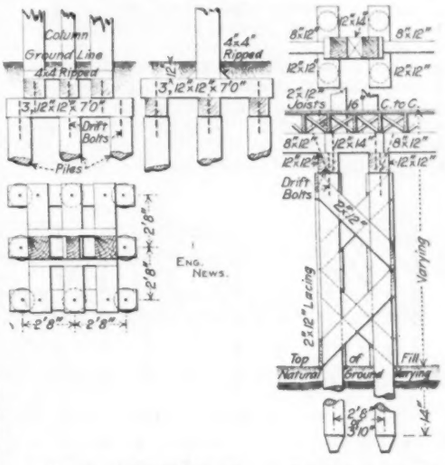

Fig. 2. Foundations of Transportation Building; St. Louis Exhibition.

Fig. 3. Type of Pile Foundations Extending Above Ground.

sleepers of floor.—B, Natural ground at a depth of 7 to 9 ft. below the adopted street grades, the area within the building filled up to floor grade.—C, Natural ground from 1 to 6 ft. below floor line, ground sound for spread footings, floor on joists, girders and posts.—D, Natural ground from 2 to 12 ft. below floor level and soft (old park lagoon basins and watercourse channels), main floor built upon joists and girders supported by posts or piles.—E, Filled ground over entire building area or part of it (the filling done before foundations of building were placed), floor resting on sleepers on filled ground.—F, Filled ground same as under D, but filling not brought up to floor level, floor carried on joists and girders supported by posts or piles.

In the Varied Industries Building, conditions mentioned under A and B were met with. The floor rests on sleepers on natural or filled ground throughout. The foundations are all spread footings, with timber cribbing for heavy loads; sills and planks cross-wise underneath for walls, etc. The foundations for tower and dome main posts are on piles. In the Education and Social Economy Building and the Electricity Building, con-

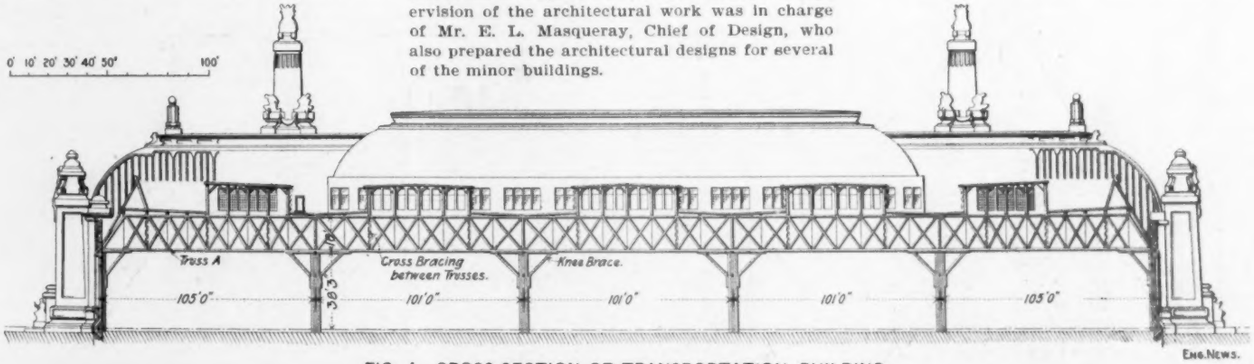

FIG. 4. CROSS-SECTION OF TRANSPORTATION BUILDING.

FOUNDATIONS.

The foundation work was designed in various ways to suit the following varying conditions: A, Natural ground at a depth of not more than 3 or 4 ft. below the adopted street grades, and the area within the building leveled and graded for

TABLE I.—MAIN BUILDINGS OF THE LOUISIANA PURCHASE EXHIBITION AT ST. LOUIS, MO.

Buildings.	Architects.	Contractors.	Area covered. Sq. ft.[4]	Area under roof. Sq. ft.[5]	Size. Ft.	Contract price.	Cost per sq. ft. under roof.
Agriculture	Dept. of Works	Caldwell & Drake	818,500	809,800	500x1,600	$528,940	$0.655
Education	Barnett, Haynes & Barnett, Kansas City.	J. J. Dunnavant Co.	337,000	240,000	525x 750	319,399	1.298
Electricity	Walker & Kimball, Omaha, Neb.	Goldie Const. Co.	331,400	290,700	525x 900	399,940	1.032
Fish, Forestry and Game	Dept. of Works	Kellerman Const. Co.	175,150	175,150	300x 600	173,000	0.960
Fine Arts (main)[1]	Cass Gilbert, New York	Goldie Const. Co.	66,700	61,658	350x 175	606,387	9.883
" " (E. Wing)[2]	" " " "	" "	83,449	68,395	200x 400	167,870	2.454
" " (W. Wing)[2]	" " " "	" "	75,107	68,395	200x 400	167,870	2.454
Horticulture	Dept. of Works	Caldwell & Drake	239,440	236,940	300x 800	228,872	0.966
Liberal Arts	Eames & Young, St. Louis	Kellerman Const. Co.	399,470	391,172	525x 600	475,000	1.214
Machinery	Widmann, Walsh & Boisselier, St. Louis.	Smith & Eastman	412,800	402,016	525x 800	496,957	1.236
Manufactures	Carrère & Hastings, New York	J. J. Dunnavant Co.	611,140	577,960	525x1,200	719,399	1.246
Mines & Metallurgy	T. C. Link, St. Louis	Hill & O'Meara Const. Co.	446,992	439,600	525x 750	498,000	1.133
Transportation	Isaac S. Taylor, St. Louis.	Hy. W. Schleutter	689,278	668,700	525x1,200	692,000	1.035
Varied Industries	Van Brunt & Howe, Kansas City.	Rountree Const. Co.	552,500	447,900	525x1,200	669,000	1.494
U. S. Government	J. Knox Taylor, Washington, D. C.	Strehlow & Phelps	253,722	162,244	200x 850	873,980[6]	2.305
Festival Hall	Cass Gilbert, New York	" "	41,700	41,700	.....	218,184	5.230
Restaurant Pavilion	Dept. of Works	Goldie Const. Co.	12,400	7,040	.....	54,870	7.794

NOTES:—[1] Permanent and fireproof. [2 3] Temporary and semi-fireproof. [4] Including courts and terraces. [5] Area within main frieze line. [6] Contract price, $105,000 for the steel work, $268,980 for the rest of the work.

ditions A and B were present. The floor is laid on graded and filled ground; spread footings being used where natural ground was good, and piles where it was marshy (in old water course channels, filled in after foundations were built). The Machinery Building also offered similar conditions; its floor is all on filled ground. Foundations for main posts are all on spread cribbed footings, as much as six and eight courses in height; the area was filled in after these footings were placed. In all cases where the foundations came over the old creek beds of the "Wilderness," piles were used. Besides that, all the tower supports rested on pile foundations. In the Manufactures Building the conditions C were present; the floor is on joists and girders supported by posts; all main truss-posts and supports of entrance structures are on pile foundations. The Liberal Arts Building shows conditions A and D, the building standing half on high ground and half over the old park lagoon. All footings on the high sound ground are spread, with the only exception of the main supports of the entrance pavilions. All foundations over the lagoon are of piles, including all supports of floor girders.

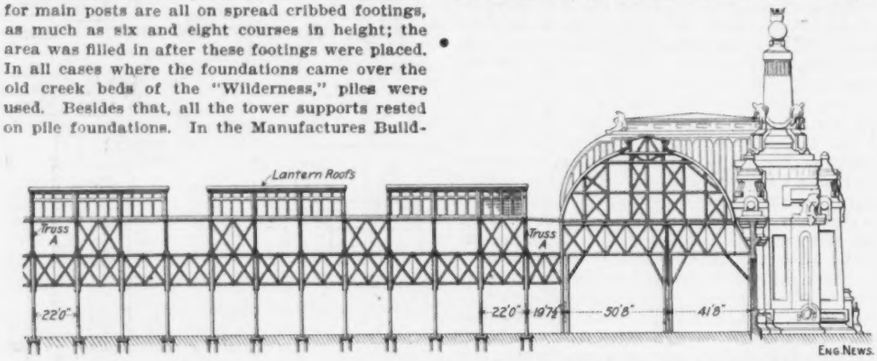

FIG. 5. PART LONGITUDINAL SECTION OF TRANSPORTATION BUILDING.

The Mines and Metallurgy Building is over low ground and pile foundations are used for all purposes. Floor joists and girders are also supported on piles. The Transportation Building is all on filled ground over part of the "Wilderness," and grading and filling was all done before building was started. The fill is so deep that excavating for footings down to natural ground was not advisable. All foundations are on piles driven through filled ground into 14 ft. of natural ground (with the exception of one corner of the building which came over high ground that was cut away). The floor is all on sleepers on the filled ground. The other buildings comprise different conditions in various parts of the covered areas, and the foundations and floors are built to suit the conditions.

DESIGN OF TIMBER FRAMING.

Long leaf yellow-pine is used for all posts, trusses and framing. The largest truss spans are as follows: 106 ft. in the Agricultural and Mining Buildings; 150 ft. in the Varied Industries; 160 ft. in the Transportation; 160 ft. in the Machinery; 95 ft. in the Liberal Arts; 92 ft. in the Manufactures, and 85 ft. in the Fish, Forestry and Game Building.

COMPRESSIVE STRESS.—The safe compressive stress of posts for centric loading (in lbs. per sq. in.) is calculated from the following formula,

$$\frac{1400}{2+\frac{L^2}{550\,D^2}}$$

where $\frac{L}{D}$ = ratio of length to least side of section:

In all cases where loads are eccentric, or where posts are directly subject to bending strains, as from knee-braces, etc., the combined compressive strain per sq. in. on the compression side of the bending stresses is kept within the value of the above expression. Where, in the case of knee-braces against posts, these posts are unsupported laterally at the heel of the knee-brace, the sum of compression due to the greatest bending moment (which occurs at this point) and the direct compression is kept within the value of the above expression. Where, however, the posts are supported laterally, at the heel of the knee-braces, the sum of the compression due to half the greatest bending moment (which occurs half-way between the knee-brace and the foot of the post) and the direct compression, is kept within the value of the above expression.

TENSILE STRESS.—While the safe tensile stress of the timber was estimated at 1,800 lbs. per sq. in., this strain is hardly ever developed. The nature of joint and connection details in timber framing is such that the dimensions of the members are generally determined by these details rather than by the stresses in the principal members, and as a rule are in excess of what the tensile stresses would require. All details for transmitting stresses from member to member are based on the following:

1. Long leaf yellow pine: 1,800 lbs. per sq. in. safe compression in the direction of the grain; 800 lbs. per sq. in. safe compression perpendicular to the grain; 150 lbs. safe shear parallel to and in the direction of the grain. 2. White oak: 400 lbs. per sq. in. safe shear parallel to the grain in a lateral direction.

This latter case of shearing stress occurs in the oak keys which are used throughout the construction for the following purposes: 1, to make the shear connections between the individual sticks of timbers used in the built-up posts which are subject to the combination of stresses due to direct compression and to bending strains. The longitudinal shear due to bending in posts is transmitted from piece to piece by these keys. 2. To make all tension splices of jointed timbers break joint wherever they occur; for instance, in the long bottom chords of trusses (which are generally built of two parallel sticks). Each stick, in this case, is of such size that its net cross section will carry 75% of the total chord tension, so that every joint of each stick can be made by transmitting 50% of its stress (25% of the total chord tension) to the other stick running by and the other 50% to a special splice pad on the outside of the chord. All this by means of the oak keys packed with bolts as described. 3. To make all attachments to posts, trusses, etc., where a force parallel to these members has to be transmitted to them.

These keys are white oak, turned to 2 ins. diameter, driven into holes bored after individual timbers are assembled and bolted together. After the keys are driven into place the bolts are screwed up hard. Theoretically, square keys, used as a pair of wedges, are unquestionably superior to these keys of circular cross section, because they admit of tightening up in case the shrinkage of the timber makes it necessary (especially in structures which are to have a longer

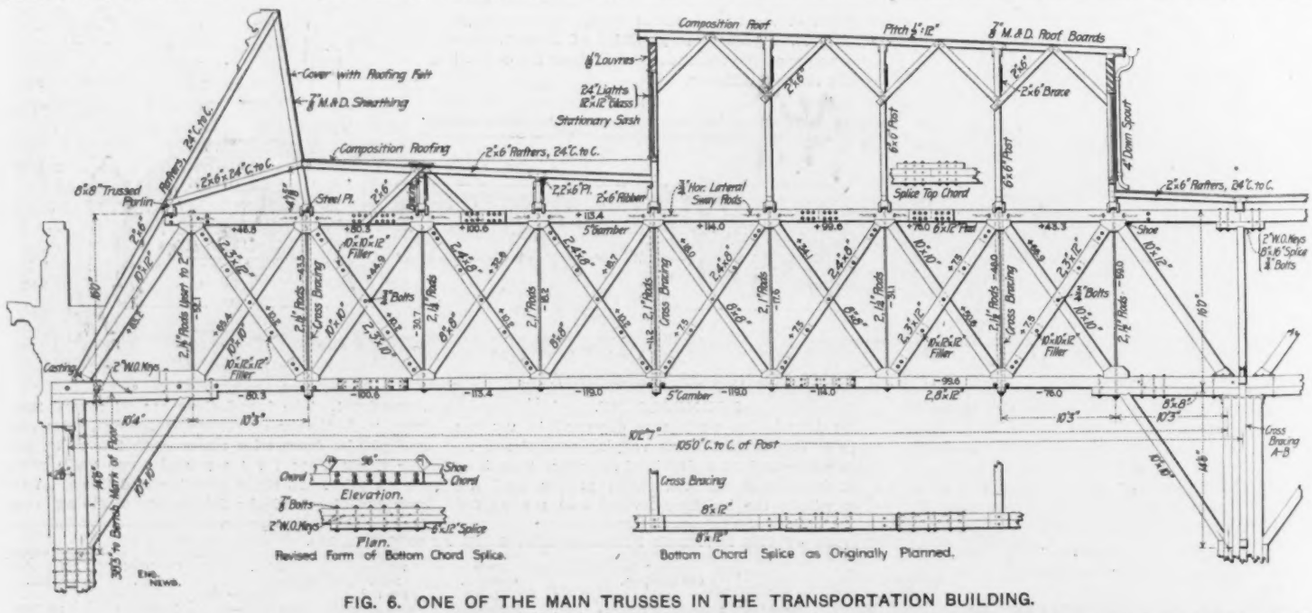

FIG. 6. ONE OF THE MAIN TRUSSES IN THE TRANSPORTATION BUILDING.

period of existence than these exhibition buildings), and because the pressure of the shearing strain upon square keys does not develop a component laterally, as with the round keys. But it was felt that the practical superiority of the round keys cannot be questioned when the small cost of labor required for these keys, the extraordinarily large number of such key connections, and the certainty of a uniformly close fit of all keys, are taken into consideration. The holes for keys and for bolts were bored with augers operated by compressed air.

The timbers have to be packed against these keys by bolts; their size and number is determined by assuming their combined tension to be equal to the total shear transmitted by the keys. The coefficient of destructive shearing across the grain assumed as 400 lbs., as above stated, means a capacity of 800 lbs. of shear-transmitting strength per lin. in. of these keys, a compression of 800 lbs. perpendicular to the grain of the oak, and a corresponding pressure against the end grain of the yellow-pine of 800 lbs. per sq. in.

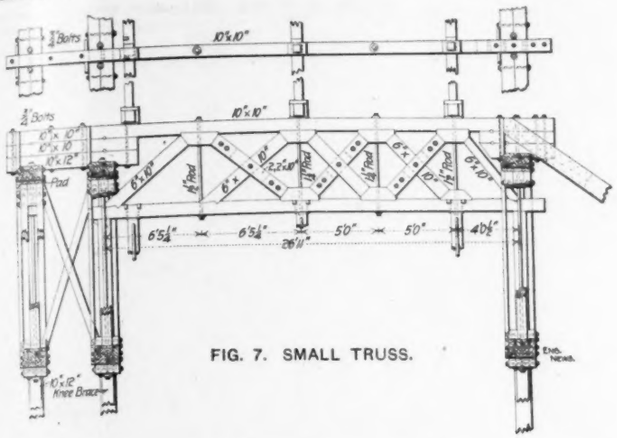

FIG. 7. SMALL TRUSS.

STEEL SPLICES.—Some of the construction drawings (see Fig. 6) show steel splices for joints in posts and truss chords, where it has been said that such splices were made as keyed timber splices. It is explained that these steel splices were used in the earlier constructions, for the reason that timber pad splices were avoided under the impression that they would be unsightly. But it takes very careful workmanship to make these steel splices satisfactory. The bearing lugs riveted to the steel plates, very frequently two or more at each side of the joint, can hardly ever be expected to all have a close uniform bearing in the grooves cut for them, and very frequently even the same lug has not a close fitting bearing across the width of the timber. The strength of the joint, on account of such imperfect fitting, is materially decreased where the inspection of workmanship is not very rigid. The workmanship in the timber splice, on the other hand, cannot help but be good and the bearing on all keys uniform, as explained above. The later work was all done with keyed timber splices, and even some of the work detailed with steel splices was revised before execution and timber splices were substituted.

COMPUTATION OF TRUSS STRAINS.

DEAD LOADS.—The dead loads supported by trusses and posts are closely estimated, by approximate assumptions, and are verified or corrected after sizes of truss members, etc., are determined from the stress diagram. These dead loads consist of the following: (A) The weight of the truss itself. The weight of the bottom chord, all butt blocks and struts are applied as loads at lower panel points. The weight of top chord and vertical rods are applied as loads at upper panel points. (B) The weight of cross trusses, generally two or three, acting as sway braces in alternating bays (in only a few cases occurring at every panel point), and the dead load of roof rafters, sheathing and covering supported by them, applied as loads at the respective lower panel points of the main trusses. (C) The dead loads of trussed purlins and roof rafters with the sheathing and covering supported by them, applied as loads at the upper panel points.

LIVE LOADS.—In addition to these dead loads a uniform live load of 10 to 15 lbs. was assumed, for snow or other incidental loads.

WIND.—The wind pressure was assumed as 20 lbs. against 1 sq. ft. of vertical surface or the projection of inclined surfaces. For the strains of timber members resulting from wind forces, the same stresses are allowed as for dead and live loads. For the strains of steel rods resulting from wind forces, a higher stress is allowed than for the dead and live-load strains; 15,000 lbs. per sq. in. is allowed for stresses due to dead and live-load strains; 18,000 lbs. for stresses due to wind force strains, so that, generally speaking, the stresses occurring in steel rods from the combined application of wind forces and loads are between the limit of 15,000 and 18,000 lbs. per sq. in.

In some cases where the dead-load tensile strains are counteracted by wind force compressive strains, the tension in such members becomes a maximum for dead and live loads only. In cases where the load tensile strains receive an increment from the wind force strains, the tensions in such members are a maximum for the combined application of loads and wind forces and lie between 15,000 and 18,000 lbs., the actual amount in each individual case depending on the proportion of load strain to wind force strain.

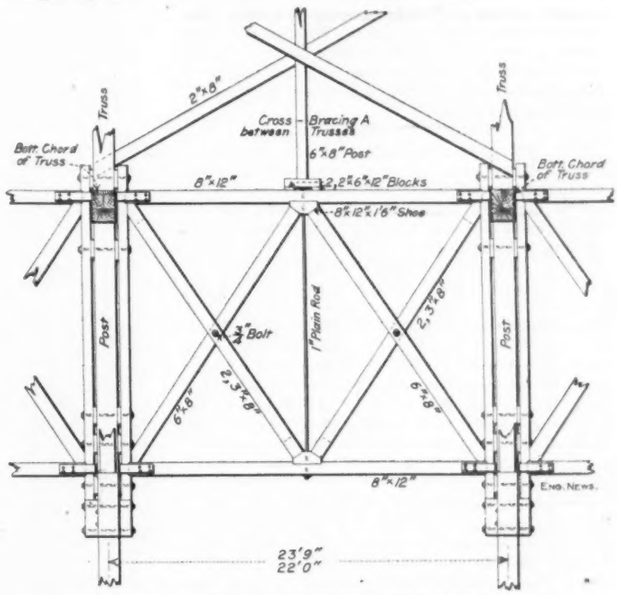

FIG. 8. CROSS-BRACING BETWEEN MAIN COLUMNS.

The timber stresses allowed may be assumed as being 25% of the ultimate stresses, the steel-rod stresses, assuming 64,000 lbs. as the ultimate strength of the material, are $\frac{1}{4.25}$ of the ultimate strength for the dead and live loads only, and $\frac{1}{3.5}$ of the ultimate strength for wind forces only, but since the wind force strains always occur in combination with the load stresses, the combined stress lies between $\frac{1}{4.25}$ and $\frac{1}{3.5}$ of the ultimate stress, or is approximately also 25% of the ultimate stress. Thus, for a higher wind pressure than 20 lbs., say 30 lbs. per sq. ft., the factor of safety of 4 of the construction would be reduced to a value between 3 and 4.

It may be further stated that there is an additional margin of strength against wind pressure in the fact that the framework of the walls of the buildings, stiffened by the sheathing, is capable of resisting a certain amount of the shear; the roof forming a solid plane of sheathing over the entire building transmits a portion of the wind pressure to all walls not running normal to the wind direction. This element of strength in addition to

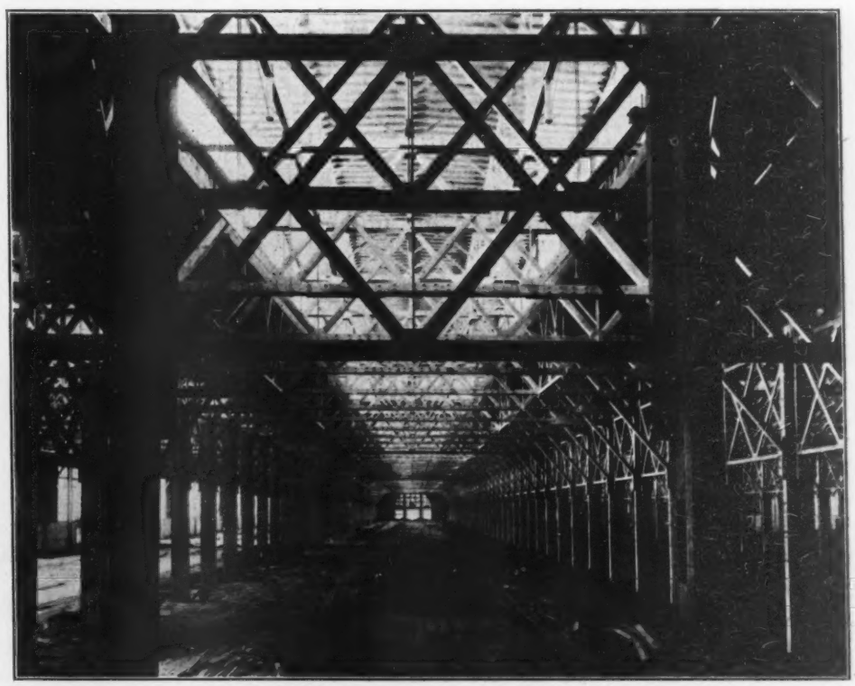

FIG. 10. INTERIOR OF THE TRANSPORTATION BUILDING.

the strength of the main framing of posts, knee braces and trusses, may be counted upon in assisting the principal framing in cases of higher wind pressures than these spoken of above.

With one or two exceptions, the roof loads are transmitted to the trusses at panel points, the rafters running parallel to the trusses and supported by cross trusses or trussed purlins, as above mentioned. Where rafters span from main truss to main truss, as, for instance, in the large Agricultural Building, the additional compression due to bending strain has been added to the direct compression, and this value has been used in the compression formula.

ROOF COVERING.

Flat roofs with grades suitable for composition roofing have been arranged for wherever the architectural design does not call for steeper pitch gable, mansard or curved dome roofs. In the latter cases, prepared felt roofing with lapped and cemented joints is used.

DOME OF FESTIVAL HALL.

The Festival Hall is worthy of attention for the construction of its dome roof. There are four main piers in the circular plan of the auditorium, and two main posts are erected in each of these piers, forming the principal square above which the inner dome is mounted. The outer dome overlaps this inner dome. Four principal Howe trusses span over the square plan; above these (and at 45° with them) another prism of four Howe trusses is erected, and above these another prism, etc. There are five such systems of four trusses each, mounted one above the other, until the open space is spanned. As shown in Fig. 1, the ends of the trusses in each upper course rest on the middle of the top chords of the trusses below. This framing affords supports for a radial system of posts supporting polygonal rings of purlins carrying the rafters of the outer dome shell, 84 ft. radius. The weight of roof and ceiling rafters, furring, staff, plaster, snow, etc., is 57 lbs. per sq. ft. of area covered (snow being taken as 10 lbs. per sq. ft.). The trusses, purlins, posts and bracing of dome weigh 36 lbs. per sq. ft. of area covered (main posts supporting trusses not included).

The ground upon which this structure had to be erected forms a deep cavity with filled-in ground all around it, and a very extensive substructure was required up to the main floor of the building. The foundations of the eight main posts up to the main floor are built in the form of strongly braced trestles resting upon concrete footings.

WEIGHT OF BUILDING MATERIALS.

In Table II. are given the weight and board measure per sq. ft. of surface covered for the trusses, posts, purlins, knee braces and cross braces, and lateral rods, but excluding the rafters and roof sheathing.

TRANSPORTATION BUILDING.

As an example of the construction of these great timber buildings, we take the Transportation Building, since it is fairly typical of the character of the general construction, although the length and arrangement of spans varies in all the buildings, while each has certain details peculiar to itself. As this building is on filled ground, pile foundations are used, each column resting on a cribbing of heavy timbers on a group of piles. This is shown in Fig. 2, which represents the foundation for one of the main columns (Fig. 9). The lengths of the piles are determined by assuming that a penetration of 14 ft. into the natural ground will be sufficient to comply with the requirements of the specifications for not more than 2 ins. penetration under the last blow of a 2,000-lb. hammer falling 30 ft. Piles of greater length were used where necessary to comply with the above specification. The floor is laid on sleepers embedded in the ground. The 14 tracks in the building are laid with 60-lb. rails on sawed ties 8 × 10 ins., 30 in. c. to c. Upon the ties, between and outside the rails, are filler strips 3 × 4 ins., laid flat; to these are spiked the 2-in. flooring planks. The exhibit spaces will mainly be finished with maple flooring.

A style of pile bent foundation used in some of the other buildings where the floor line is above the ground level, is shown in Fig. 3.

The Transportation Building is 1,200 ft. long and 525 ft. wide, and its general structural design

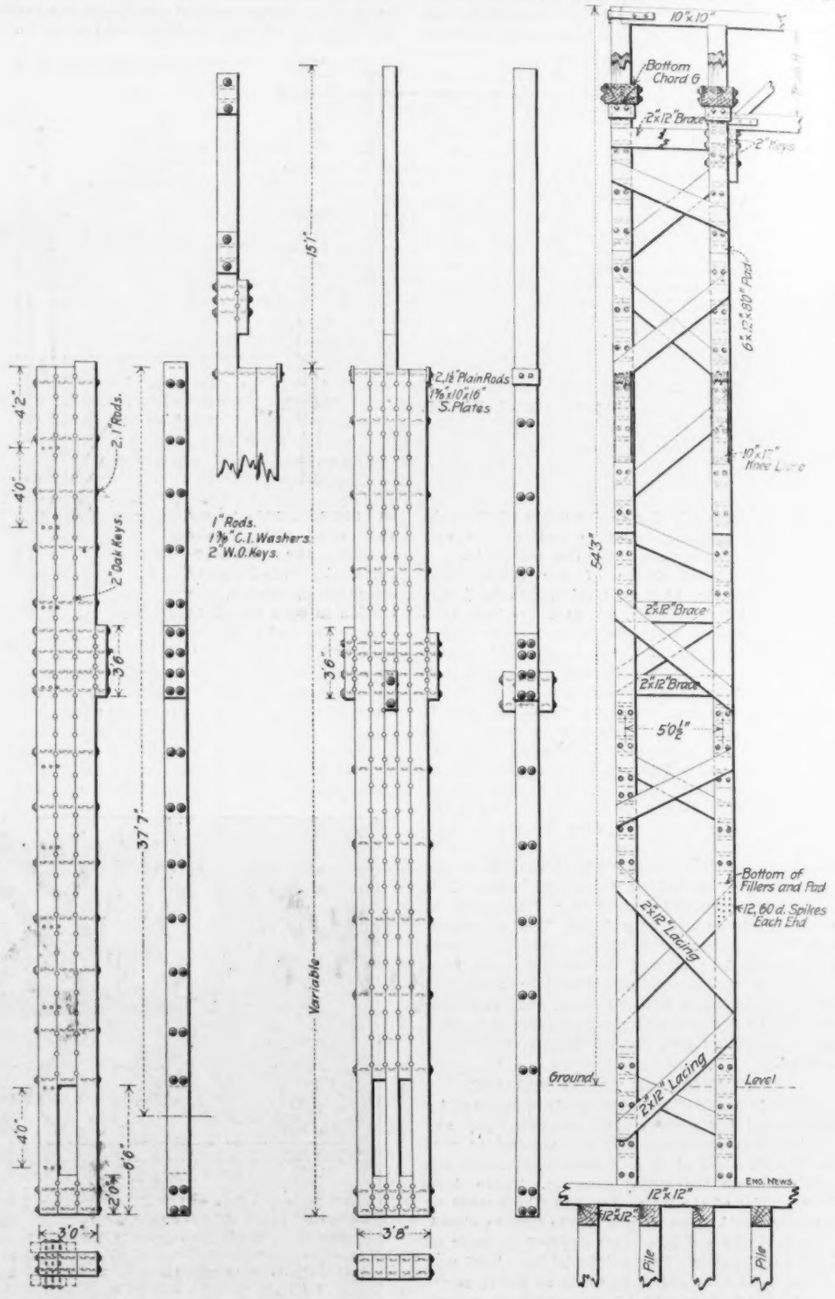

FIG. 9. COLUMNS OF THE TRANSPORTATION BUILDING.

TABLE II.

Buildings.	Height to bottom chord.	Weights of Building Frames per Square Foot of Horizontal Area. Trusses, braces and purlins.			Posts.			Total.		
		Wood		Metal	Wood		Metal	Wood		Metal
	ft. ins.	ft. B.M.	lbs.	lbs.	ft. B.M.	lbs.	lbs.	ft. B.M.	lbs.	lbs.
Agriculture	47 8	1.87	7.00	0.85	1.12	4.18	0.25	2.98	11.18	1.10
Education	52 6	1.41	5.29	1.05	1.67	6.27	0.31	3.08	11.56	1.36
Electricity	53 2	1.72	6.45	1.38	1.29	4.82	0.52	3.01	11.27	1.90
Fish and Game	47 4	2.34	8.97	0.50	0.97	3.62	0.34	3.31	12.59	0.84
Horticulture	39 0	2.12	7.94	0.63	1.38	5.21	0.53	3.50	13.11	1.16
Liberal Arts	36 0	2.82	10.59	2.23	0.73	2.76	0.35	3.55	13.35	2.58
Machinery	41 0	2.53	9.51	1.95	1.02	3.82	0.23	3.55	13.33	2.58
Manufactures	38 3	3.58	13.71	2.57	1.34	5.02	0.58	5.02	19.14	3.15
Mines	50 3	2.89	10.94	2.30	1.30	4.88	0.41	4.19	15.77	2.71
Transportation	40 3	3.81	14.37	1.89	1.04	3.95	0.33	4.95	18.32	2.22
Various Industries	55 3	2.03	7.61	2.12	1.51	5.66	0.45	3.54	13.28	2.57

is shown by the sections in Figs. 4 and 5. The width is divided into five spans, two of 105 ft. and three of 101 ft. The trusses of these spans are 22 ft. apart, with lines of cross bracing between them. Fig. 6 shows the details of one of the main trusses, 105 ft. c. to c. of columns, 16 ft. deep, with 5 ins. camber. The design of chord splices has already been described, and the drawing shows the joints with steel splices as originally planned, and also with the wooden splices afterwards adopted. This drawing shows the high monitor roof construction. All the trusses are of the same general type, and an example of the smaller trusses is shown in Fig. 7, which represents a 25-ft. truss. In the main spans, knee braces extend from the column to the first panel of the bottom chord, as

shown in the cross-section, Fig. 4. Between the main columns and beneath the level of the bottom chords of the trusses is a continuous line of cross bracing, as shown in the longitudinal section, Fig. 5; the details of this bracing are shown in Fig. 8.

The construction of the columns is shown in detail in Fig. 9. The main columns are each composed of three posts (two 10 × 14 ins. and one 8 × 14 ins.) with two sets of filler pieces 8 × 14 ins. Some of the columns for the smaller trusses are composed of two posts 12 × 14 ins., with a single set of filler pieces of the same size. These timbers are put together with 2-in. round oak keys and iron through bolts. This design has already been discussed. In some special cases in other buildings, large columns of skeleton construction are used. These have four or six posts with horizontal braces and struts between them and diagonal plank latticing on all four sides.

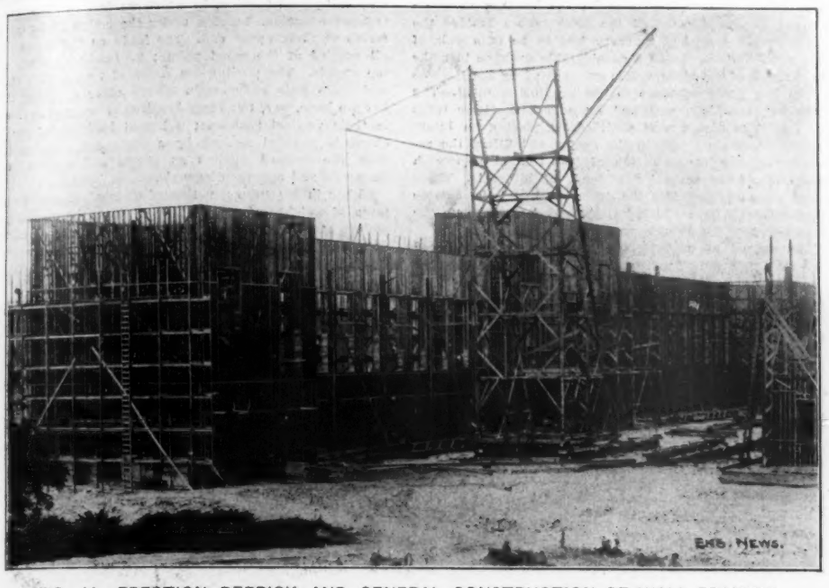

FIG. 11. ERECTION DERRICK AND GENERAL CONSTRUCTION OF WALL FRAMING.

The general interior view, Fig. 10, is taken looking along one of the main lines of trusses of 101-ft. span. It shows the lower longitudinal bracing between the columns, the upper longitudinal bracing between the trusses, and the knee braces from the columns to the trusses. It also shows the main columns, composed of three posts and two fillers, while in front (at the right) appears a column built up of two posts and one set of fillers. At this post, also, will be noted the diagonal rods running parallel with the longitudinal knee braces. In the building itself, the tunnel appearance of each span (which is rather noticeable in the photograph) does not exist. The great area of side windows and the high and wide monitors or lantern roofs over each main span make the building remarkably light. The sides of these monitor roofs are fitted with louvres in the upper third, while the lower part has glazed sashes. Alternate sashes are swung on horizontal pivots and operated in groups, so as to provide ample ventilation as well as light.

The erection of the trusses and other parts put together on the ground was effected mainly by traveling derricks working backward through each bay of the building. One of these derricks is shown in Fig. 11, and the view also shows the character of the wall framing.

GENERAL REVIEW OF STRUCTURAL DESIGN.

The following particulars of the general features of the design are taken from a paper read before the St. Louis Architectural Club by Mr. P. J. Markmann, Chief Building Engineer of the Exhibition:

In our large exposition buildings we have a large area which must be roofed over and inclosed on all sides. The architectural design of the building determines to a certain degree the scheme of the constructive design. Practically only the ground floor is used as exhibit space. Galleries have been arranged only in a very limited extent, enough in the several buildings for offices of the department chiefs and their help, and for the accommodation of the guards.

The architectural designs of nearly all the buildings call for a greater height than should be expected in view of the manner in which the interior space is used. A uniform cornice height of 60 ft. was laid down to govern the designs of the exposition architects, as it was assumed that the buildings would have galleries for exhibit floor space. The plans of all the buildings which came in first showed these galleries. The authorities who were placed in charge of the exhibit department decided against these galleries as undesirable, for the reason that a comparatively small number of the general class of visitors will ascend to the galleries when their time does not seem enough to even let them give their attention to all the exhibits they find spread before them on the ground floors.

Referring to the elevations of the several buildings, it may be stated that the Varied Industries Building, as an example, with a general cornice level of 60 ft. above grade, has a height of 95 ft. from grade to the top of the attic roof parapet. The corresponding height of other buildings is as follows:

Education	77 ft.
Electricity	75 "
Liberal Arts	91 "
Mines and Metallurgy	83 "
Manufactures	105 "

Of the Machinery Building it may be said that the cornice level regulation was applied to the special features, viz.: the corner and center pavilions, and the curtains between these flanking features were kept down to their logical level for a one-story exhibit interior. The lighting and airing of the more central areas of the building, too far away from the facades, is attained by elevating the roofs of alternate naves and thereby obtaining space for monitor lights and louvres. The Transportation Building is another example where a similar logical treatment has been applied. The roof cresting of this building is about 63 ft. above ground.

Another change that has been made is the elimination of the interior open courts, as a measure of economy principally. A great amount of exhibit area was at once gained with no additional cost, since the original designs made these courts very elaborate and ornate, and the omission of all this easily pays for the additional posts and roof over these courts. The only buildings with interior courts are the earlier ones. The Varied Industries Building has a court of about 19% of the area between outside walls; the Education, 27%; the Electricity and Machinery, 12%, and the Manufactures Building, 7%.

FIG. 12. A VIEW OF THE ELECTRICITY BUILDING.

To the constructor the general problem is to furnish a framework to carry the roof over these large areas, and to form an attachment for the exterior walls forming the envelope of the building. Special features of the architectural compositions, as towers, pavilions, domes, etc., require a special consideration and treatment for themselves.

Let us consider one of our buildings of a rectangular plan, say 325 ft. wide and 750 to 1,600 ft. long. Most of

these buildings are divided in their width in five spans of roof trusses of about 90 to 100 ft. each, resting upon posts for support. The spaces between these trusses are about 25 ft. wide. Trusses of the Howe type and detail are generally used. A wind against the side of the building for the length of one bay thus acts upon a line of five trusses and is transmitted to the ground through the successive posts. The horizontal force applied to the truss, lengthwise, is delivered to the top of the post supporting the truss.

To find the required strength of the several trusses in all their individual members, it becomes necessary to determine the stresses in them under different conditions of loading. We may have the dead load only acting upon the truss, we may have a snow load in addition to the dead loads, we may have wind loads together with the dead loads, the wind may blow against the building from the left or from the right side. A number of strain diagrams, generally three, have to be made to find the maximum stresses of any one of the members in any one of the trusses. The truss members are then built for the greatest compression or tension that may come upon them.

A reversal of stresses, from compression to tension, under different loading conditions, can hardly occur in Howe trusses under our ordinary conditions. A certain strut which has a compression stress in one loading condition might have a tensile stress in another loading condition, but in this latter case the other strut running crosswise to it in the same panel enters into action and relieves the former one of all the strain.

The compression in the top chord and the tension in the bottom chord due to dead loads may be reduced by the influence of wind forces, but not sufficiently to reverse their strains. Howe trusses generally have all panels countered, with the exception of the end panels; they form very stiff trusses and can quite well stand unexpected uneven loading, such as piles of material during construction. To be sure, the truss looks as if it had a good many members to share the strains, but it may be well to mention that generally in any one panel under any condition of loading there is but one diagonal strut of the two that is under a strain. A truss with, for instance, 8 panels, having 8 main struts and 6 counters (14 diagonal members in all) has under any conditions of loading only 8 diagonals under compressive stresses, the other 6 are slack and idle. I make mention of this because the erroneous impression is frequently met with in the minds of people who have no clear conception of the analysis of truss strains that, for instance, the pressure that comes down one strut towards the bottom chord goes up into the counter which rests on the opposite side of the same angle block.

I have said before that Howe trusses, generally, in their most common use as bridge trusses, for instance, are without counters in the end panels, but where there is a possible condition of loading that would bring a tension into the end struts, even these struts will have to be countered. We have frequently found it necessary to do so in our roof trusses. The original design of the Liberal Arts Building provided an interior court about 200 ft. wide; we spanned the remaining space around this court with one span of about 145 ft. These trusses were naturally quite heavy, their weight was about 34 tons. The posts under these spans to resist the bending moments brought by the stresses of the knee braces besides the direct weight they had to carry had to be of a pair of good-sized timbers spread a considerable distance to make the moment of the force couple represented by the stresses in the two posts adequate to the bending moment. The shear between them was met by a regular Howe truss framing. The design was modified by placing an intermediate continuous post in the center and filling the remaining spaces on each side of this central post with blocks of timber several feet long, at intervals. These blocks were connected to the center post and the outside posts with oak keys and bolts; the oak keys take up the shear between the outside posts.

This method of building the posts has been followed from that time on. The two posts are connected together either directly with a line of keys, or where they are placed a distance apart with a line of shear blocks through the center, or where the space between the main posts is too wide for a reasonable sized block, a continuous neutral post is placed in the center with shear blocks at each side. (See Fig. 9.) The system of keyed posts is more satisfactory, the older system of connecting the pairs of posts with pieces of planks spiked to the sides of the posts is not so positive on account of the uncertain value of the shearing resistance of spikes, although they are undoubtedly greatly assisted by the friction between the posts and planks, when the latter are thoroughly spiked. No definite values, however, of the amount of friction developed between the bearing surfaces of the timbers are known. The 145-ft. truss spans for the Liberal Arts Building, mentioned before, were a feature of the original plan, for which the bids ran so much in excess of the appropriation that the whole building was revised and the court was omitted.

I have spoken so far of the wind bracing of the building in a lateral direction. As described, the trusses span in the direction of the width of the building, giving a comparatively much smaller number of posts in a line than we have in the length of the building. The posts, while of greater number through the building lengthwise, are not so strong against a bending moment in this direction. In nearly all cases, however, we have arranged one tier of trusses at each end of the building, running square to the end. By this arrangement we get two posts with their greater transverse strength, on account of their position with respect to the direction of the wind against them, and we build these two posts and the truss over them strong enough to resist the greater part of the pressure. The balance is carried on to the long series of posts, and part of it may reach the other span with its two strong posts, at the opposite end of the building.

All interior posts, lengthwise, are braced by what we may call portal bracing, by which we develop their lateral resistance against bending under the action of horizontal forces at their upper end. The loads on the trusses are all applied at the panel points; no bending moments in top chords. The purlins are sticks of timber with struts and truss rods underneath. Every other or every third bay we have, say, two cross bracings to secure the trusses in their vertical positions; a lateral buckling of the top chord is guarded against by a horizontal truss system, with the trussed purlins as struts and steel rods of diagonals and counter diagonals.

Ricker in his "Construction of Trussed Roofs" gives a table of weights of trusses per sq. ft. of horizontal projection of roof for trusses constructed of timbers and iron rods, and also for trusses entirely constructed of wrought iron. He states the table is made from data given by different authorities, but he does not state whether these weights cover cases where the truss is used as a member of a knee-brace bracing system to transmit a horizontal wind force to the ground. The table does probably not include the additional strength and consequently additional weight required to meet such wind strains and seems to be for trusses of triangular form for pitched roofs. The figures given for wooden trusses are 3.7 lbs. per sq. ft. for a 70-ft. span, 4.25 lbs. for 80-ft., 4.75 lbs. for 90-ft., and 5.25 lbs. for 100-ft. span.

These figures tell us that the lumber used in posts, trusses, cross bracings and purlins is equivalent to a layer of wood from 4 to 5 ins. thick spread over the ground area, and, calculated in the same way, the iron of every description used in these parts is equivalent to a thickness of nearly 1-14-in. spread over the ground area. The Manufactures Building covers a ground area of about 526,000 sq. ft. The lumber of the truss and post framing would amount to about 526,000 × 5 = 2,630,000 ft. B. M. Since the total lumber bill probably amounts to about 10,000,000 ft., the item of 2,630,000 ft. represents only about 26% of the total bill. The balance of 74% is used for roof rafters, roof sheathing, flooring, floor joists, floor girders, cribbed foundations, floor posts, also the outside special walls and other walls and all the other framing and furring for the special features of the architecture and for the staff and plaster throughout.

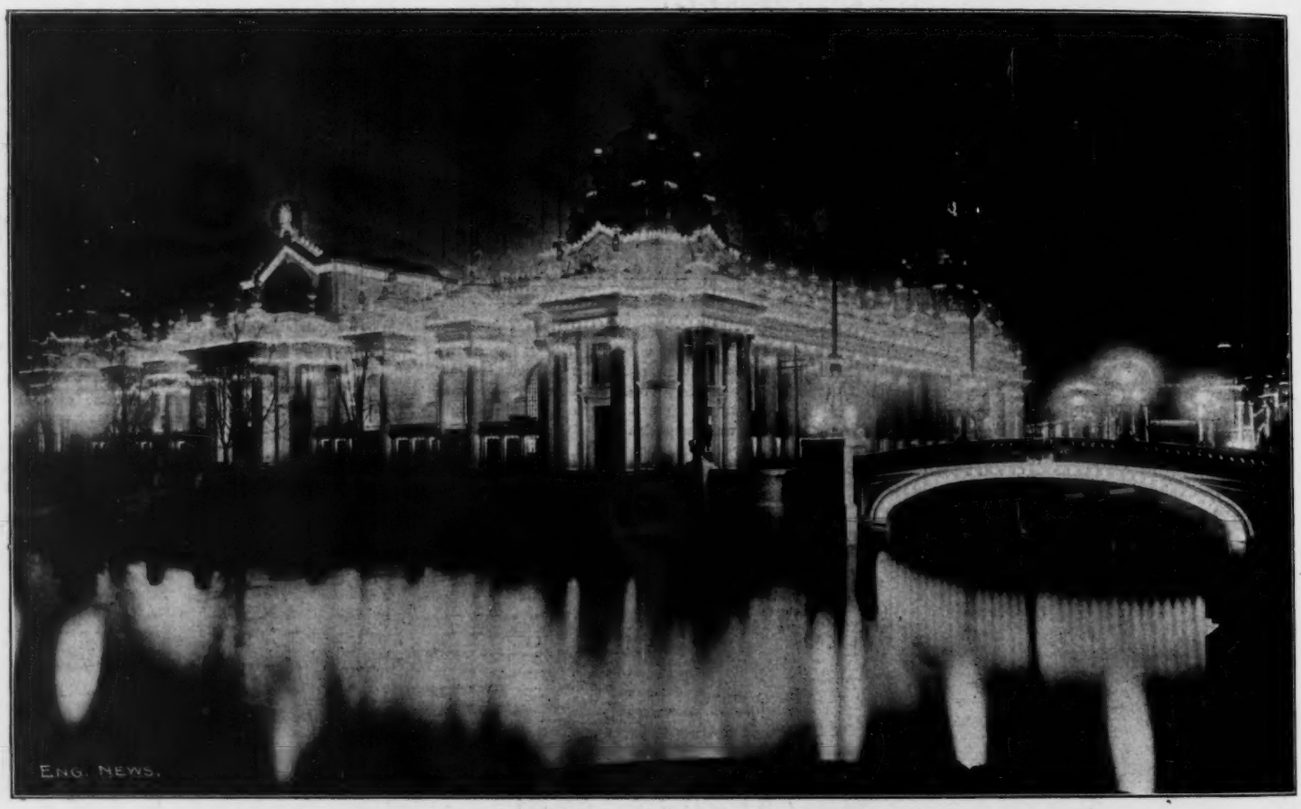

FIG. 13. THE ELECTRICITY BUILDING AT NIGHT.